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THE UNIVERSITY OF ALBERTA

A COMPARISON OF THREE ENCODING STRATEGIES ON THE SHORT-TERM RECALL OF DEAF CHILDREN

BY

© MAXINE JENNER

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF EDUCATION

IN

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DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

FALL, 1987

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "A Comparison Of Three Encoding Strategies On The Short-Term Recall Of Deaf Children", submitted by Maxine Yvonne Jenner in partial fulfillment of the requirements of the degree of Master Of Education.

P. Mulcahy
Supervisor

Date June 19/1987

ABSTRACT

The recall process used by both deaf and hearing children is related to the manner in which information is encoded. Prelingually deaf children who use sign language encode information mainly through visual and kinesthetic channels. There is a need to develop recall strategies specifically suited to the encoding style of the deaf, in order to compensate for differences between the deaf and the hearing, particularly with regard to short-term ordered recall.

This study investigated the effect of three encoding methods on short-term free and ordered recall with a group of 36 prelingually deaf children who ranged in age from 6 to 12 years. The strategies used included a visualization strategy in which signing was prohibited; a manual strategy which required signing; and a spatial strategy which included signing, as well as demarkation of each item in visual space. Each subject completed all six subtests using the three strategies, with both picture and letter materials.

The results showed that both the spatial and manual strategies were more effective than the visual strategy for free recall of pictures or letters. Differences between the spatial and manual strategies were nonsignificant for free recall.

With ordered recall, the spatial strategy was superior

to the manual and visual strategies for pictures. Differences between the manual and visual strategies were nonsignificant for pictures. For letters, differences between the spatial and manual strategy were nonsignificant, however both the spatial and manual strategy were significantly better than the visual strategy.

One conclusion was that the kinesthetic input from the signing component in both the manual and spatial strategies improved the absolute number of items recalled. The spatial strategy specifically improved recall for order.

These results reinforce the need to continue research regarding the learning and processing styles of the deaf, in order to develop methods to meet their unique needs and characteristics.

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CHAPTER I

Introduction

Memory plays a central role in human learning, and research has frequently been directed toward investigation of the memory processes used by both normal and exceptional learners. Prelingually deaf children who communicate through the use of sign language represent one group of exceptional learners with a unique pattern of concept development based on visual and kinesthetic input (Karchmer, Allen, Belmont, Bourg & Trybus, 1981; Stall & Marshall, 1984; Tomlinson-Keasey & Kelly, 1978).

The deaf process semantic features (Frumkin & Anisfield, 1977; Moulton & Beasley, 1977), and use categorization (Hoemann, Andrews, & Derosa, 1974; Liben, 1979) in a similar manner to the hearing. The main short-term recall differences between the deaf and the hearing appear to be related to surface coding features, temporal and spatial processes associated with communication mode, and sensory encoding modalities in short-term memory.

Various rehearsal strategies including labelling (Liben & Drury, 1977), cumulative rehearsal (Bebko, 1984; Belmont, Karchmer & Pilkonis, 1976), and manual signing (Stall & Marshall, 1984) have been used successfully by the deaf to improve recall. However, not all forms of rehearsal used by

the hearing are beneficial for all deaf children. The hearing tend to use a speech-based code for short-term recall (Baddeley, 1966; Conrad, 1962, 1964; Hintzmen, 1967), and so vocalization strategies are common with the hearing. Although the deaf may encode information through phonetic or visualization processes which are similar to the hearing (Hanson, 1982), there is evidence that vocalization rehearsal may be detrimental to deaf children who do not code information phonetically (Conrad, 1970, 1971). One way to determine if deaf individuals are using phonetic encoding is through evaluation of acoustic confusion errors in ordered recall (Conrad, 1972, 1973).

Deaf individuals may also encode information through sign language parameters which are unique to the deaf. (Bellugi et al., 1975, Poizner, Bellugi & Tweney, 1981; Shand, 1982). The organizational principles of American Sign Language rely on the use of visual space to convey meaning. The spatial nature of American Sign Language may be related to the tendency for deaf children to have a spatial as opposed to a temporal orientation for ordered recall (Das, 1983; Hermelin & O'Connor, 1973; Karchmer et al., 1981).

The deaf show memory deficits in comparison to the hearing, particularly with ordered recall tasks (Bellugi, Klima, & Siple, 1975; Conrad, 1970; Hanson, 1982a; Macdougall, 1979; Wallace & Corballis, 1973). Ordered processes contribute to sequential flow of information in

the English language for such tasks as reading and spelling, so they are particularly important for deaf children, who are at risk for language deficits (Krakow & Hanson, 1985).

Although a number of strategies have been used with the deaf, no strategy has been taught to improve performance specifically in ordered recall tasks. A strategy which capitalizes on the natural spatial preference of deaf children may be effective for ordered recall. Although spatial rehearsal strategies are not common, deaf children have been observed spontaneously pointing in visual space, or touching the fingertips to indicate order in recall tasks. (Bebko, 1984).

This study addressed the need to investigate strategies for ordered recall in deaf children. Three sensory encoding strategies including visualization, manual encoding, and a spatial encoding strategy were compared for short-term recall. The spatial strategy combined manual encoding with spatial organization techniques which are characteristic of American Sign Language.

Pictures and letter tasks were used in order to judge the effectiveness of strategies for materials which vary in imagery and familiarity. Serial position effects were analyzed to determine the impact of the various strategies on the serial learning curve. The present study also evaluated the degree of phonetic processing through tabulation of acoustic confusion errors in letter recall.

It was hoped that this study would contribute to a better understanding of the learning processes used by deaf children who communicate through sign language, in an effort to develop specific strategies geared to their unique needs and characteristics.

CHAPTER II

Selective Review Of The Related Literature

The study of the cognitive processes used by deaf individuals is both complex and challenging. Most theories regard the deaf as thinking and learning in the same way as the hearing, with the exception that they experience tremendous gaps in the developmental process. Tomlinson-Keasey and Kelly (1978) proposed a difference model to conceptualize the development of cognitive functioning in the deaf. Their main premise is that "limited accessibility to auditory symbols during the prelinguistic years yields an information processing system that is significantly and systematically different from that of hearing children" (Tomlinson-Keasey & Kelly, 1978, p. 455).

Stall and Marshall (1984) agreed with the difference model in their commments that "the deaf constitute a unique subgroup of the hearing impaired population [and] the absence of all vocal signal stimulation from the human sensory experience results in a unique pattern of concept development based entirely on visual and kinesthetic input" (p. 31). Others have observed that, as a result of this unique sensory processing, the congenitally deaf "often spontaneously employ alternative strategies that seem to reflect unique structural orientations" (Karchmer et al.,

1981, p. 8).

If the deaf do differ from the hearing in terms of their cognitive structure, it can be expected that differences may be apparent in terms of memory functions. Memory plays a central role in human learning. "There will be no evidence of learning without something having happened in memory; by the same token, something happening in memory implies learning" (Lefrancois, 1982, p. 236).

The deaf frequently fall below the hearing in terms of a number of parameters associated with memory. Bellugi et al. (1975) found in their study of ordered recall that short-term memory span (the list length at which half the lists were correctly recalled) was 4.9 items for the deaf adults and 5.9 items for the hearing. Other researchers have also found poorer performance by the deaf in comparison to the hearing on ordered recall tasks. (Conrad, 1970; Hanson, 1982a; MacDougall, 1979; Wallace & Corballis, 1973).

Rather than dwelling on the absolute differences between the deaf and the hearing, recent research has instead focused on discovering what process differences exist between these two groups that lead to different levels and patterns of performance in memory tasks. A "difference" model has the potential to identify these unique cognitive functions and strategies used by the deaf, in comparison both to the hearing and to other groups who show language delays or deficiencies. This in turn may stimulate the

development of programs and therapeutic techniques geared to the unique learning or processing styles of the deaf. Most models of memory acknowledge the role of sensory awareness and sensory processing as the first stage in the recall process. The reliance on a different combination of sensory systems may have important implications for the memory functions of deaf individuals.

The deaf population itself is composed of two groups: those who communicate using oral speech, and those who rely on the use of sign language. Although there is overlap between these groups, individuals tend to have a preference for either oral or manual communication. The communication mode used by deaf individuals is related to methods that they use to encode and process information. This paper focused on members of the deaf population who relied on the use of sign language, since it is this group who are most likely to be using nonacoustic cognitive processes. It is important to understand the elements of sign language communication, since these appear to be related to generalized cognitive processes, as well as memory processes in deaf individuals.

Sign Language and Cognitive Processes

A number of different sign languages exist. Some, such as Signed English or Signed Essential English (SEE) have been created by educators to duplicte English syntax,

morphology, and word order in order to teach deaf children to understand English. The Rochester Method, which requires fingerspelling of the letters in words of sentences using English word order, is another method used to teach English. Fingerspelling uses a specific hand configuration for each letter of the alphabet.

These "English" methods don't represent the natural communication medium of the deaf who use sign language. "Natural" sign languages differ among countries as do spoken languages in terms of the signs themselves and the syntax which is used. In North America, Bellugi et al. (1975) noted that American Sign Language (ASL) "is likely to be the communication prelingually deaf people use among themselves and the gestural communication used among deaf families" (p. 98). Many deaf individuals are "bilingual" in the sense that they use American Sign Language (ASL) as a primary language, and English as a second language in such tasks as reading, or conversing with individuals who use an English sign system.

American Sign Language is a visual-gestural language with organizational principles that differ from spoken words. Individual signs differ in terms of three parameters including hand configuration, place of articulation and movement pattern (Bellugi et al., 1975). For example, the same hand configuration and movement is used to make the signs for WOMAN and MAN, but the signs differ in terms of

the initial place of articulation (on the cheek or at the side of the forehead).

English and ASL show essential differences in the form of their symbols, in the way they are combined (syntax) and in the principles used to modify meaning of the English word in comparison to the ASL sign (Bellugi et al., 1975). Spoken language is temporal in nature, with the component elements of words being linearly organized (ie boat and vote differ in initial segments), and sequentially arranged. In contrast, "signs are not sequential arrangements of elements [but] can be better understood as simultaneous combinations and recombinations of various hand configurations, types of movements, and places of articulation" (Bellugi & Fischer, 1972, p. 176). For example, VOTE and TEA differ in movement occurring throughout the sign, but the specification for hand configuration and location are identical. The simultaneous nature of ASL in comparison to the temporal nature of spoken English has been examined in relation to the performance of the deaf in tasks requiring simultaneous versus sequential processes in short-term memory, and this will be subsequently examined in more detail.

Related to the simultaneous nature of ASL, is the degree to which ASL utilizes visual space to convey meaning. Most signs are made in an area bounded by the head and the waist, and the signer's hands return to a base plane in front of the body at the end of the phrase. Changes in movement

"placed" in space can be used to reflect the spatial arrangement of objects in relation to the speaker or each other (Bellugi & Fischer, 1972). For example, the arrangement of objects on a table can be duplicated by making the signs for the objects in duplicate space in front of the body.

Interest in visual space and sign language has led to investigation regarding the role of visual perceptual abilities in sign language use. Siple, Hatfield and Caccamuise (1978) administered four tests of visual perception to hearing impaired college students and hearing staff members. Students were divided into a High Manual Reception group (fluent signers) and a Low Manual Reception group (poor signers). The subjects were retested four months later, following intensive sign language instruction for the Low Manual Reception group and hearing staff members. There was no clear pattern of differences in visual perceptual ability among the three groups on initial assessment, and on reassessment all three groups had improved equally.

Although this research does suggest that the deaf do not have inherently superior visual perceptual abilities in relation to the hearing population, this does not preclude the deaf from using visual space in a way which is not normally accessed by the hearing population, but is particularly suited to the communication medium of the deaf.

It is possible that the advantages associated with ASL and visual space could be maximized through application to other cognitive processes such as memory. It is worthwhile to bear this in mind as attention is turned to the investigation of memory processes. Research regarding the deaf has generally been in comparison to the hearing. From this perspective it is worthwhile to review the major models of memory postulated for the hearing population .

Models of Memory

A model of memory proposed by Craik & Lockhart (1972) focusses on the type of processing used to analyze incoming information. Perceptual and sensory modalities are initially important to analyze physical features of objects (surface codes), however ongoing analysis leads successively to processing on a deeper semantic level. The ability to remember information will depend on the meaningfulness of the material and the depth of processing.

An alternate model of memory proposed by Atkinson and Shiffrin (1971) divides memory into two dimensions, including permanent invariant structural features, and control processes which vary with the requirements of the task. The structural dimension has three components including the Sensory Register (also called iconic or echoic memory), Short Term Store (STS, also called primary memory), and Long Term Store (LTS, also called secondary memory).

Information enters the Sensory Register where important information is filtered, but it is not recognized until it enters the STS.

The STS, or working memory contains the control processes which operate on the conscious information in the STS. Control processes retrieve information from LTS into STS where it is related with new incoming information. Decision making to select material for LTS, as well as coding and rehearsal are also functions of the control processes. The STS contains a memory buffer which has a small fixed storage capacity and is considered to be important in rehearsal strategies. The exact size of the buffer varies with the type and amount of information which is to be remembered in the specific situation. According to the Atkinson and Shiffrin model, the LTS is a passive permanent memory store which has an unlimited capacity.

In the hearing population, "there is a general consensus that developmental changes in the structural components of memory have at most only a small impact on the observed age-linked increments in memory performance while changes in control processes have a dramatic effect" (Liben, 1984, p. 241). Research has been directed both toward the structural components of memory as well as the use of efficient control processes. Because the control processes may be modified through behavior, the methods used to encode, process, and recall information have received considerable interest.

Encoding Processes in Short-Term Memory

One important area which has received research interest in terms of short-term memory is the manner in which information is coded into short-term memory. Stimulus encoding is an important stage in information processing for cognition. "Representation or encoding may be modality specific and retained in one of the five senses for varying periods" (Stall & Marshall, 1984). Since the signing deaf population use different sensory modalities to encode information, the interaction between internal structures and task materials for the deaf in comparison to the hearing, is of particular interest.

One commmon material used for recall tasks is words. Words may be high in visual or auditory imagery, and these attributes have variable effects on recall depending upon the processing and coding modes of the recipients. For example, blind people recall word pairs with high auditory imagery (with auditory referents) more easily than words with low auditory imagery, while normal (hearing and sighted) people recall word pairs more easily with high visual imagery (Paivio & Okovita, 1971). Visual Imagery indexes for high and low imagery words are similar in the deaf and the hearing (Tweney, Hoemann & Andrews, 1975).

In sign language, some words are fingerspelled since they have no sign equivalent, while other words are assigned

a specific sign. A word which is easily signed has a a high "signability rating". Conlin and Paivio (1975) compared the effect of visual imagery and signability word attributes on the recall of sixteen year old deaf and hearing subjects in a paired associate task. Word pairs were rated as high in both signability (S) and visual imagery (I), low in both S and I, low I and high S, or high I and low S. The high imagery words facilitated recall in both groups, but the signability dimension facilitated recall in the deaf group only. An interaction was also found, in which signability showed greater effect for pairs that were high in imagery.

The deaf subjects reported using a manual signing strategy to aid recall, and used this strategy more often with high signability than low signability pairs. While both groups reported using an imagery strategy particularly with high imagery pairs, the hearing subjects reported using it more often than the deaf. Hearing subjects reported using a vocalization strategy more often. The conclusion was that "gestural signs, visual features (perhaps related to ASL) and visual images seem to play major roles in their [the deaf's] symbolization of verbal material... provide further evidence that alternative encoding modes can be used effectively" (Conlin & Paivio, 1975, p. 340).

Somewhat analagous to the variable of imagery attributes of words is the iconicity associated with signs. Iconicity implies that the form of the sign is related to the form of

what the sign denotes. For example, the sign for window is high in both imagery and iconicity because the window can be visualized, and sign for window mimics opening a window. On the other hand, the sign for doll has high imagery because the doll is easily visualised, but it has low iconicity because the sign for doll is unrelated to the form of the doll.

Poizner et al. (1981) investigated iconicity and short-term recall with deaf college students. Immediate ordered recall was required for lists that were four items long. They found that formationally similar signs interfered with ordered recall, however semantic similarities, or iconicity had no effect on short-term ordered recall.

The deaf have also been compared to the hearing in terms of phonetic coding processes. For hearing people, short-term memory for letters and words typically uses a speech-based code regardless of whether the words are spoken (Baddeley, 1966; Hintzmen,1967) or written (Conrad, 1962, 1964; Kintsch & Busche; 1969; Murray, 1967, 1968). Speech-based coding in the hearing begins to emerge at about 5 years of age (Conrad, 1971). The hearing tend to verbalize the items to themselves, even though the presentation may be visual. Because phonological encoding is used by the hearing, acoustic similarities create difficulties with ordered recall due to acoustic confusion errors. (Conrad & Hull, 1964). Letters have frequently been used to investigate the

phenomenon of intrusion errors. Mistaking a "C" for a similar sounding "T" rather than a visually similar "O" would be an example of an acoustic confusion error. The phenomenon of intrusion or confusion errors in ordered recall has been used to investigate the encoding methods used by the deaf.

Conrad (1972) analyzed the ordered recall errors made by hearing and deaf students for visually presented consonant letter strings. The letters either showed high inter-letter acoustic similarity (BCDPTV) or high inter-letter visual similarity (KNVXYZ). The visually similar letters were selected for common diagonal components because they were most likely to produce confusion errors if visual processing was predominant.

The sequences ranged in length from four to six letters and were presented at a rate of one letter per second. Sequence length was based on the age and ability of individual subjects. The optimum length was the one at which there were enough errors to make a feasible comparison between the two types of stimuli, but not so many errors that the task was impossible. Eighteen sequences of each of the acoustic and visual letters were presented, with a requirement for immediate written ordered recall.

An Articulatory Index (AI) was calculated based on the proportion of all errors that were articulatory based. The mean AI for the hearing group was .70, for the oral deaf

group .37, and the nonoral deaf group .30. There was greater variability among the oral deaf group, with 8 out of 40 having an AI above .50. None of the 56 in the manual deaf group had an AI above .50, while only 2 out of 32 hearing subjects had an AI clearly below .50. Conrad (1972) concluded that the hearing were using an acoustic or articulation strategy, whereas the deaf were using a non-acoustic strategy which was possibly\visual or dactylic.

Bellugi et al. (1975) also compared the intrusion errors in an ordered recall task made by deaf college students in comparison to hearing students. Deaf subjects viewed videotaped ASL signs, while hearing subjects heard lists of words on audiotape. An incorrect response in a particular serial position was defined as an intrusion error.

The intrusion errors made by the hearing subjects were frequently words with phonological similarities to test words, while those made by the deaf subjects were based on the visual formation of the ASL signs, rather than the sound of the word. The majority of the errors differed in only one of the simultaneously occuring ASL parameters required to make the sign, such as hand configuration, movement pattern, place of articulation, or hand orientation.

Bellugi et al. (1975) suggested that the profoundly deaf may use a linguistic store which contains visual and/or kinesthetic representations of fingerspelling or signing hands, and further suggested that the deaf encode

information in short-term memory based on ASL parameters.

The question of whether the deaf encode information in terms of ASL parameters only because the stimuli have been presented directly in ASL was addressed by Shand (1982). He replicated the investigation of Poizner et al. (1981) and extended it by presenting stimuli in the form of videotaped ASL signs and printed words. Again the subjects were congenitally deaf college students who were fluent signers. Word lists were presented which had ASL formation similarites or phonological similarities. Dissimilar words formed a control list. The results indicated that with written or signed presentation the formationally similar lists were recalled with lower accuracy than control lists or phonologically related lists (Shand, 1982). These findings are in agreement with Bellugi et al. (1975) and Poizner et al. (1981).

Since the deaf showed the same pattern of recall interference that is observed using phonologically related lists with the hearing; it was suggested that similar processes may be used by the two populations. (Poizner et al., 1981; Shand, 1982). However, the encoding of printed words into ASL by the deaf is not completely analagous to acoustic encoding of printed words by the hearing because "unlike the simple modality switch entailed by the hearing subject recoding visual English into phonological English, the signer is switching languages" (Shand, 1982, p. 11).

Shand (1982) suggested that there may be a universal tendency to code linguistic material into a system which is a "primary" or basic linguistic code for each individual. This would be a phonological code for most hearing people, but a sign-based code for deaf people whose primary language is ASL. According to Shand, the preference for using a phonological code may be due to the language experience of subjects rather than to any intrinsic superiority of a phonological code to retain linguistic material.

Shand's findings of an ASL encoding effect for printed words are in agreement with earlier findings by Odom, Blanton and McIntyre (1970). Odom et al. (1970) compared deaf students (mean age 16 years) with hearing fifth graders (mean age 10.4 years) who were aproximately equivalent in reading ability. Subjects were given a paired associate task in which they were required to recall a signable or nonsignable word in conjunction with a numeral. Although the words were presented visually, and not overtly rehearsed, a significant advantage was found for signable words for both the deaf and the hearing, with a greater advantage for the deaf. Facilitation of signable words in the hearing may have been due to higher visual imagery in the signable words, since this was not controlled in the experiment by Odom et al. (1970).

Although strong evidence has been found for short-term memory encoding based on manual coding parameters, the deaf

may also use speech coding. Conrad (1970) found that some oral deaf children were using auditory articulatory encoding, but they "were not as uniformly or strongly effected by auditory-related conditions as hearing persons" (Furth, 1971, p. 66). Conrad (1973) found that deaf subjects who used a speech-based code recalled more in an ordered recall task than those who didn't use a speech-based code. Deaf individuals with high speech coding indexes tended to have good speech quality and hearing. Speech hearing was a much better predictor than pure tone hearing, but intelligence as measured by the nonverbal Cattell test wasn't related to speech coding (Conrad, 1973).

Hanson (1982a) administered a probed ordered recall task using printed word lists to deaf (native signers) and hearing college students. The deaf students had a hearing loss of at least 70 dB, and 11 of the 15 subjects had a loss greater than 90 dB. The lists showed similarities in sign representation (i.e., name, knife,); phonetic qualities (i.e., two, blue,); or graphemic qualities (i.e., bear, meat,). Both groups showed a performance decrement only with the phonetically similar words in comparison to its control list.

A second group of deaf subjects received an ASL videotape of the words. These subjects were less accurate on formationally similar words or phonetically similar words in comparison to sets of control words, while the graphemically

similar set was equivalent to a control set of words. The subjects spontaneously signed and mouthed the words, although the signer on the videotape maintained a neutral expression.

Hanson (1982a) suggested that the stimulus input influenced the encoding strategy used by the deaf subjects. The ASL videotape had stimulated the use of sign-based encoding by its deaf viewers, and this produced the observed decrement in performance for the formationally similar signs. However, Hanson found for both videotape and printed stimuli, the deaf subjects showed speech-based encoding for ordered recall tasks.

Shand's (1982) findings of no decrement in performance for phonologically related lists are in contradiction with Hanson's findings. It may be important that Hanson's group of deaf subjects were well educated, and had also shown spontaneous vocalization rehearsal. This may imply that Hanson's subjects normally used a greater degree of speech coding, despite their severe to profound hearing losses.

For hearing adults, phonetic similarity of words improved free recall, rather than interfering with it. (Watkins, Watkins, & Crowder, 1974). In a second experiment, Hanson (1982a) compared free recall for formationally similar and phonetically similar printed words for deaf and hearing subjects. The deaf showed better performance on two out of five formationally similar lists, while the hearing

benefitted from phonetic similarity in all five sets. Hanson (1982) suggested that the deaf may not have shown evidence of phonetic coding in this task because their internal pronounciation of some words may be different. Hanson didn't adequately explain why this variable should have had a differential effect in the second experiment but not the first.

Interestingly, the overall recall of the deaf was equivalent to the hearing in Hanson's (1982a) experiment. This is in contrast to other studies which found the hearing superior to the deaf (Conrad, 1970; MacDougall, 1979; Wallace & Corballis, 1973). These studies illustrate that there may be important differences between free and ordered recall.

Krakow and Hanson (1985) compared the ordered recall of congenitally profoundly deaf college students who were fluent signers, for ASL and printed or fingerspelled English. As in previous research, intrusion errors indicated sign-based coding of ASL signs, however intrusion errors were not apparent with printed and fingerspelled English, and there was no recall advantage for words that had a direct sign translation. Hanson and Krakow (1985) suggested that well educated deaf individuals don't translate into ASL if English is required, and "deaf bilinguals can change their recall strategies depending upon whether they are presented with information in English or in ASL" (p. 271).

Krakow and Hanson (1985) found that the mean recall was equivalent for the three types of information for the deaf, however it was significantly less than that of the hearing subjects. Since Hanson (1982a) had shown that the deaf were equivalent to the hearing on free recall, Krakow and Hanson (1985) suggested that their results indicated difficulty specifically with ordered recall. They argued that difficulty with serial order doesn't interfere with ASL because ASL depends to a greater extent on simultaneous production of linguistic components, while English depends on word order for syntactic organization.

They concluded, "If we are to improve our methods for teaching deaf persons to read and write, it is crucial that we gain more insight into the strategies that deaf individuals bring to bear when remembering English letters, words, sentences, and the ways in which deafness effects the perception of memory for sequential flow of linguistic information" (Krakow & Hanson, 1985, p. 271).

Related to the issue of ordered recall is that of temporal and spatial processing in the deaf. These processes will now be examined in more detail.

Temporal And Spatial Processes

O'Connor and Hermelin (1972) suggested that one could infer the organizational nature of a child's cognitive structures through his interpretation of an ambiguous

request. They investigated this hypothesis through a request to report the "middle" when there was the choice of a temporal, spatial, or numerical middle digit.

Three visual digits were presented in the right, middle, or left location to hearing and deaf children. In a similar task, aural digits were projected through the right, middle, or left speaker to sighted and blind children. The results showed that the temporal middle position was consistently reported by the blind and hearing children in the aural condition. In the visual test, both deaf and hearing children reported the spatial middle digit.

A follow up study by O'Connor and Hermelin (1973) used a similar task in which 3 digits were presented sequentially on three screens, but not in left to right or right to left order, with a requirement for free recall of the 3 digits rather than the middle digit only. Both the hearing and deaf children showed over 90% accuracy, however the hearing children reproduced the digits in original temporal order, while the deaf children reproduced the digits in left-to-right spatial order. O'Connor and Hermelin (1973) concluded that the deaf preferred a spatial orientation in contrast to the temporal orientation preferred by the hearing.

Further research investigated their ability in this area. Hermelin and O'Connor (1973) then used a recognition task which required children to decide on each trial if a comparison sequence was the same as an input sequence.

Temporal (TE), spatial (SP) or random arrays were administered in one window with the comparison sequence in a multi-window sequence, or vice versa. The judgement of a TE or SP orientation was made if the child correctly recognized twice as many of one type of array as the other.

The results showed that 8% of hearing children, and 54% of deaf children showed a SP orientation. Younger deaf (mean age 10.6) were equivalent to older deaf (mean age 13.0) when the input was temporal and the output spatial. However, when the input was spatial and the output was temporal, 80% of the younger deaf were SP, in comparison to 36% of the older deaf. The conclusion was that although there was high variability in the deaf population, there was a tendency for younger deaf children to have a SP orientation.

Conrad and Freeman (1975) used the TE/SP tasks with young hearing children. At age five the ratio was 40% TE versus 45% SP, while at age eight the ratio was 80% TE as compared to 15% SP. Freeman suggested that the increased reliance on TE in the hearing was due to increased reliance on articulation. The SP orientation in the deaf may be related to a greater reliance on visual processing and strategies.

Not all studies in this area have shown such consistent results toward a SP orientation in the deaf and a TE orientation in the hearing. O'Connor and Hermelin's (1973) study was replicated by Beck, Beck and Gironella (1977).

Both oral and manual deaf students (mean age 10.6) were compared with hearing students (mean age 8.5). The results indicated that there were no significant differences between the deaf and hearing groups in terms of temporal/spatial preferences. Neither the hearing children, or the orallly trained deaf children showed the expected temporal preference. In fact, the bias was toward a spatial preference. A second experiment was conducted with hearing university students to determine if the results were related to the age of the participants, but "once again we failed to confirm the temporal bias in normal individuals" (Beck et al., 1977, p. 551).

Das (1983) essentially replicated the study by Beck et al. (1977) with deaf children age 8 to 11 years, and second and third grade hearing students. In addition to a free ordered recall condition, a probed recognition task was added. In the free recall condition the deaf children showed equivalent recall for temporal and spatial order, however the deaf children showed poorer performance in the temporal probe than spatial probe condition. Differences between the deaf and hearing students were nonsignificant on all tasks.

Deaf and hearing children have been compared on variety of visual memory tasks involving both temporal and spatial demands. McDaniel (1980) compared deaf and hearing children ranging in age from 10 to 13 years for immediate recall of

simultaneously (spatial order) and successively (temporal order) presented pictorial visual material. Although the hearing children performed better on a few isolated tasks at different age levels, the overall results indicated that both groups performed equally well on both types of these tasks, which had no language component.

Karchmer et al. (1981) identified the initial tendancy used by deaf and hearing children (CA 11.5) for ordered recall of TE/SP letter strings. Each child's initial structure was then stressed by requiring him to use the other reconstruction order. A second session followed in which both orders were required, and stress was adjusted through the presentation rate to determine optimal processing efficiency under the two conditions. The results indicated that initially 9/16 of the deaf group (56%) had a SP orientation, while all of the hearing group used a TE orientation. When hearing children were required to adopt the SP orientation they initially showed a marked decrease in accuracy of recall, but adjusted quickly and showed almost total recovery of accuracy. The deaf children showed less decrease in accuracy of recall in the nonpreferred condition, but were slower to recover. Although the SP and TE oriented deaf children showed similar recall efficiency, the TE oriented children were slower to respond. "These findings suggest that profoundly deaf children at age 11 years are better adapted to the spatial orientation than the

temporal, and that the minority of deaf children who spontaneously chose the temporal orientation may, in fact, have been handicapped thereby" (Karchmer et al., 1981, p. 5).

In agreement with Conrad and Freeman (1975), Karchmer et al. (1981) suggested that the complex spatial information required to understand American Sign Language (ASL) may explain why many deaf students spontaneously choose a spatial rather than temporal orientation.

The general conclusion which can be drawn from this discussion is that the deaf, and particularly young deaf children tend to have a preference for a spatial orientation, although this is not universal. In terms of implications for strategy use and training, it would be logical to build on this orientation and investigate ways to represent temporal material through the use of visual space. Although few techniques have specifically been designed to capitalize on visual spatial abilities to maximize recall, a number of rehearsal strategies have been used successfully to improve performance in recall tasks. This area will now be examined in more detail.

Rehearsal

Rehearsal involves repetition of items to maintain their presence in short-term working memory, or to promote the transfer of items to long-term memory. The buffer model of

short-term memory by Atkinson and Shiffrin postulates that "information about an item is copied into LTS during the period of time that it remains in the buffer; in fact the amount of information transferred is a linear function of the amount of time the item spends in the buffer" (Bourne et al., 1986, p. 82). The more time spent on rehearsal in the short-term memory buffer, the greater probability that the item will enter the LTS.

Research with hearing children has found that older children are more likely to use overt rehearsal as well as report using covert rehearsal than are younger children. (Flavell, Beach & Chinsky, 1966). Rehearsal has been shown to promote superior recall in hearing children who use spontaneous rehearsal in comparison to those who don't as young as the first grade level (Keeney, Cannizzo & Flavell, 1967).

Studies have assessed the use of rehearsal both directly through observation of subjects, and indirectly through analysis of serial learning curves. In serial order tasks, subjects are required to remember the position and identity of a series of items. Items which are presented at the beginning (primacy effect) and at the end of the list (recency effect) are generally remembered better. According to Atkinson and Shiffrin's buffer model, the primacy effect occurs because the initial items that are learned stay in the buffer until it is full, are in the buffer longer than

the subsequent items, and so are remembered better. This explanation of the primacy effect relates to rehearsal in short-term memory. The recency effect is attributed to the idea that the final items are still in the STM buffer at the time of recall. According to the buffer model "the middle and primacy portions of the curve reflect retrieval of information from LTS, whereas the recency portion reflects largely retrieval from STS" (Bourne et al., 1986, p. 86).

Liben and Drury (1977) investigated the use of rehearsal strategies by two groups of deaf children. The younger group had a mean age of 6 years 3 months, and the older group had a mean age of 8 years 8 months. Children were educated using the Rochester fingerspelling method, which is supplemented by an oral approach. Serial learning tasks were administered in which the stimulus materials included pictures of familiar animals which were easily named, and line drawings of nonsense forms which were not readily named. A set of lower case print letters, or the same letters accompanied by pictures showing the manual alphabet handshape, were used to investigate manual kinesthetic rehearsal.

As expected, the overall performance on the animal forms was significantly better than the performance on the nonsense forms, with recall of print or manual alphabet letters being lower. However, strong primacy effects were found for all four stimulus materials for both age groups. Liben and Drury (1977) observed that the children

spontaneously labelled pictures and invented labels for nonsense forms, although there was little evidence of cumulative rehearsal. Because primacy effects are generally attributed to cumulative rehearsal rather than labelling only, Liben and Drury (1977) hypothesized that some children may have been using some form of undetected covert verbal rehearsal or visual imagery strategy, and that these deaf children spontaneously used these rehearsal strategies regardless of whether an English label was available.

Swanson (1982) compared hearing students to profoundly deaf children (mean age 12.54 years) on a probe-type ordered recall task for nonsense drawings in a named and unnamed condition. The deaf children normally relied on the use of sign language. Overt rehearsal was prevented, however strong primacy effects were found for both the named and unnamed condition in the hearing, but only for the named condition in the deaf. Recency effects were apparent in both conditions for both groups. Recall performance was better in the named condition for both deaf and hearing children, however the deaf students showed poorer recall than the hearing students in both conditions.

Liben and Drury's (1977) findings of primacy effects with their oral deaf group are consistent with those of Swanson (1982) for the group who relied on signs. Prevention of overt rehearsal may have contributed to the absence of primacy effects for the deaf with unnamed nonsense forms for

Swanson (1982), while they were present with similar stimuli for Liben (1977), who allowed spontaneous rehearsal.

Chi (1976) suggested that the improvement in recall in named conditions could be due to acoustic or articulatory storage rather than cumulative rehearsal. Other suggestions which have been made to explain this phenomenon include the idea that the name may assist in semantic representation of the item, and "given a meaningful name, normal and deaf children may accommodate processing levels in terms of semantic codes" (Swanson, 1982, p.26). The importance of semantic codes will be examined in more detail in the following section of the review.

Belmont et al. (1976) compared congenitally deaf subjects (age 18) to hearing subjects (age 20) on short-term serial probe recall for consonant letter strings six or seven items long. In a free strategy condition the normal subjects responded more quickly and accurately than the deaf subjects. Following strategy instruction using repetitive fingerspelling as a rehearsal technique, the recency portions of the serial learning curves were equivalent, however the deaf showed a smaller primacy effect than the hearing. Belmont et al. (1976) suggested that the deaf may have deficiencies in the area of secondary (LTS) memory, although the use of letter strings may have interfered in some way with long-term memory search.

Belmont et al.'s (1976) findings that letter strings

showed poorer recall is consistent with Liben and Drury's (1977) findings of a larger recency than primacy effect for letter strings in comparison to pictorial stimuli.

Krakow and Hanson (1985) examined the effects of linguistic material which was presented in different forms, when they compared the ordered recall of congenitally profoundly deaf college students for ASL, and printed or fingerspelled English. A recency advantage and a primacy disadvantage were found for both ASL signs and fingerspelled words in comparison to the printed words. Krakow and Hanson suggested that dynamic stimuli such as fingerspelling and signs produces different serial position curves than static stimuli such as print.

Bellugi et al. (1975) also found bowed serial position curves with large primacy and recency effects in their experiment which tested ordered recall for ASL videotaped signs. Consistent with Belmont et al. (1976), and Krakow and Hanson (1985), the primacy effect for the deaf was smaller than for the hearing, and the primacy effect was smaller than the recency effect. The primacy effect covered the first two items for the deaf, while it covered the first three for the hearing. Bellugi et al. (1975) attributed this difference to a slower rate of production of signs versus speech, and suggested that the implicit signing in STS rehearsal is also slower, resulting in a proportional decrease in rate of transference of items into LTS, and a

smaller primacy effect for the deaf.

If the deaf do show a smaller primacy effect due to slower sign production, the question arises whether it would be possible to increase the redundancy of the sign image in some other way, so that although the sign takes more time to produce, it "stays longer" simultaneously with other sign information. This could possibly be accomplished through better use of "visual space" in rehearsal.

Bebko (1984) compared deaf children who were educated by the oral/aural method and the total communication method (aged 5 to 14 years) regarding the types and efficiency of the rehearsal used to perform memory tasks. Eight colors were shown sequentially for 3 seconds each, with a 15 second delay after the series. The subjects then arranged colored blocks in the presentation order.

Subjects were classified as producers if they spontaneously used or reported a rehearsal strategy on at least two of the six trials. Producers and nonproducers were randomly assigned to a rehearsal teaching condition, or an interpolated task condition. In the interpolated condition, subjects counted to prevent rehearsal in the 15 second delay, while in the teaching condition, children were instructed to use cumulative rehearsal.

More than 50% of the oral deaf children showed spontaneous rehearsal at age 10 to 11, while the total communication group showed the same pattern at 12 to 13

years. In contrast, the hearing control group showed spontaneous rehearsal at age 7-8. (Bebko, 1984).

In terms of recall performance, the nonproducers in all 3 groups were equivalent, however the hearing producers recalled more than either of the oral or manual deaf producers on the baseline condition. The deaf producers showed superior recall in comparison to the deaf nonproducers, particularly in the primacy positions, which is consistent with the effects of rehearsal. The teaching condition showed longer sequence length recall in comparison to the interpolated condition.

Bebko (1984) concluded that the initial lower performance of the deaf on the baseline condition was related to unreliable or inefficient spontaneous rehearsal. These conclusions are in agreement with those of Belmont et al. (1976). However, when rehearsal was used, the probability of correct recall was .54 for the deaf in comparison to .84 for the hearing, indicating some possible interference with efficiency of rehearsal for the deaf. Bebko suggested that deaf children appear to be able to retain information as well as hearing children if it is encoded accurately, and that training in rehearsal strategies is warranted.

In Bebko's (1984) study, verbal rehearsal was generally used by the oral deaf students, while the manual deaf students generally used signs or unintelligible

verbalizations. This is consistent with observations by Beck et al. (1977). Interestingly, some children used spatial strategies to organize the sequences, including counting the colors on the fingertips or placing the color on an imaginary place on the tabletop and then touching the location while rehearsing. Bebko (1984) labelled these strategies as "idiosyncratic", however they are compatible with the spatial nature of ASL, and may be indicative of the type of strategies which could be used to encode information in a way that is most compatible with the nature of sign language.

Although deaf students who rely on manual communication are frequently encouraged to use vocalization simultaneously with manual rehearsal, Conrad (1970, 1971b) found that manual and oral deaf students comprehended passages equally well when reading silently. However, when the manual deaf students were instructed to read aloud, their comprehension decreased significantly. Conrad concluded that deaf children don't all use the same code, and required vocalization actually interfered with performance when it wasn't a normal strategy for the deaf individual. The overall conclusion was that recall could be impaired by using the wrong encoding strategy.

The effect of prevention of manual encoding has been studied with the profoundly deaf. Stall and Marshall (1984) tested 24 prelingually deaf adults (age 14 to 46 years) who

used fingerspelling as their primary communication method. A paired associate learning task was administered in which a number was paired with a picture of a noun which was easily signed. When the number was presented later, recall of the picture was required. Subjects were assigned to a manual condition (M) or a nonmanual condition (N). Those in the M condition were encouraged to use signs to rehearse as the material was presented, while those in the N condition were prevented from manual rehearsal by encasing their hands in foam, with the fingers spread apart.

The M group showed faster and greater learning. "The results testify to the central role of overt manual signing as an encoding modality for learning in deaf subjects who use manual communication" (Stall & Marshall, 1984, p.36). These findings indicate that it would be appropriate to teach young deaf children to use manual rehearsal strategies in memory tasks and academic tasks such as spelling.

At the present time, manual strategies which are taught to the deaf generally entail cumulative repetition. While this is appropriate, and effective, manual strategies could be geared to the use of the visual space dimension which is so important in sign language. An organized visual spatial encoding approach may more optimally utilize the information processsing capacity of the deaf who use sign language.

The previous discussion has focused on the short-term encoding based upon "surface features" of stimuli, and the

nature of the stimuli (i.e., pictures, words, signs). There is also evidence that the deaf use semantic or conceptual features to assist recall, and this will now be explored.

Semantic Relationships

Developmental preferences for coding based on surface features vs semantic features of words was investigated by Felzen and Anisfield (1970). Hearing children (CA 8.6 years and 11.5 years) were given a false-recognition test in which a continuous list of words was heard, with semantically or phonetically (rhyming) related words appearing later in the list. As the later words were presented, subjects indicated if they had heard them before. Older children showed more false recognition responses for words that were semantically related, while younger children showed more false recognition responses to words that were phonetically related. Felzen and Anisfield (1970) suggested that "just as speech dominated short-term memory, so it also dominates the memory of young [hearing] children over longer time periods [and] their internal organization of words, the semantic factor plays a less influential role than the phonetic factor" (p. 479).

The false recognition procedure was used again by Frumkin and Anisfeld (1977) to compare two groups of profoundly deaf students (CA range 13.7 to 15.5 years; and 7.3 to 10.4 years) who attended an oral program for the

deaf. For printed words, both groups showed a false recognition effect for semantically related words and orthographically similar words. For videotaped signs, there was a false recognition effect for signs related semantically and formationally for both the younger and older group. It is interesting that the formationally similar signs were encoded, despite the fact that this group of deaf students used an oral communication mode.

Moulton and Beasely (1975) made a similar comparison for older severely to profoundly deaf subjects (CA 18 years) who relied on manual communication. Four lists of word pairs were presented that either shared a common sign formation and close semantic relation; a semantic relation only; a similar sign formation only; or were unrelated for a control list. Each pair was presented initially, then following the pair presentation, the first word of the pair was presented, while the subjects wrote the missing word.

The results indicated a semantic advantage, with word pairs sharing similar meaning-similar sign formation and similar meaning-different sign showing higher scores. The pairs showing similar sign formation only were recalled better than the control list, indicating some formational encoding, as well as semantic.

A single sign can represent several words. Moulton and Beasley (1977) suggested that because of this, formational similarities could contribute to confusion in paired

associate tasks. However, performance on the lists with common sign-similar meaning was not different from performance for pairs with similar meaning or similar signs. Moulton and Beasly concluded that effects of the semantic and sign cues weren't additive.

It appears that deaf individuals may be able to switch coding systems depending on the requirements of the situation. "At least two coding strategies may be used (sign or semantic) by the hearing impaired and ... coding on a semantic basis rather than coding by signs may be more efficient in the initial stages of a verbal learning task" (Moulton & Beasley, 1977, p. 565).

A theory for the mechanism for semantic encoding in the deaf was proposed by Moulton & Beasley (1975). Semantic coding may occur in STM through access to stored semantic rules and associations in LTM. A reciprocal relationship between STM and LTM may explain the better recall for words with similar signs, since for awareness of the sign associations between words, encoding of the visual image of the printed words into their sign equivalents is required, and rules of association which are stored in LTM must be used to link the words.

Semantic encoding has also been evaluated through the demonstration and release of proactive interference. Proactive interference occurs in tasks with a requirement to remember items from the same conceptual category over a

series of trials, without rehearsal. A different category is presented in the final trial. The proactive interference causes poorer performance on the trials following the first trial, however the category change on the last trial releases the proactive interference, resulting in performance which is equal to that of the first trial.

Hoemann et al. (1974) used this phenomenon to compare deaf and hearing children (CA 8 to 12 years) on their ability to remember a series of 5 animal pictures followed by a final series of unrelated common objects. The results showed no significant age or sex differences, and no significant differences between the deaf and hearing subjects. Both groups showed proactive interference and its release, leading to the conclusion that "deaf children's memory on this task is functionally similar to that of hearing children and adults" (Hoemann et al., 1974, p. 430).

While the preceding study demonstrated that deaf children are aware of category membership, it didn't assess whether they use categorization as a memory strategy. Liben (1979) investigated this aspect by comparing deaf and hearing children in grade 3, 5 and 7, using a free recall task with line drawings that could be categorized. Following the first trial, half of each group was given instruction in semantic categorizing and category labels for use in the second trial. On the third trial, both the trained and untrained groups were told category labels, and the number

of items in each category.

Initially the seventh grade children showed more spontaneous clustering, but when all children were shown how to categorize, there was no difference between grades. Overall, trained subjects remembered more objects than untrained subjects. In agreement with the findings of Hoemann et al. (1974), there were no main effects for hearing status and no interactions between hearing status and training (Liben, 1979). These results indicated that the deaf and hearing subjects started to use categorizing at about the same age, and showed similar benefits from training.

Semantically based processing in relation to memory has also been assessed from other aspects. Both hearing children and adults tend to retain the meaning rather than the exact wording and syntactic structure of sentences (Sachs, 1974; Trembath, 1972). Hanson and Bellugi (1982) assessed the ability of deaf adults who were fluent signers, to detect changes in ASL sentences. ASL sentences were shown using videotape, then test sentences followed either immediately, or after presentation of intervening sentences. The task was to decide if the test sentence was identical to the original sentence in all respects. The sentences were altered on four dimensions including changes in formal sign order or lexical changes which preserved the original meaning; and semantic or inflection changes which changed

the meaning.

The subjects were able to detect all four types of changes equally well on immediate testing. On delayed testing, the inflection and semantic changes which changed meaning were noticed better than the formal and lexical changes which preserved meaning. This study also illustrated that the deaf relate to underlying meaning in a similar manner to the hearing.

These studies show that the deaf encode material categorically and semantically in addition to encoding based on sign parameters, and they may encode on a number of these dimensions simultaneously. "The conclusion that deaf persons encode sign language stimuli in terms of their formational parameters complements the conclusion that they encode categorically" (Hoemann et al., 1974, p. 430). This is also compatible with findings that the hearing code information on multiple dimensions simultaneously (Wickens & Dalezman, cited in Hoemann et al., 1974). These findings from semantic research indicate that some memory processes of the deaf and hearing are functionally similar.

Summary

The review of the literature has revealed similarities and differences in the recall processes used by deaf and hearing individuals. Semantic features (Frumkin & Anisfield, 1977; Moulton & Beasley, 1977), and categories (Hoemann et

al., 1974; Liben, 1979) are recalled in a similar manner by the deaf and the hearing. Recall differences between the deaf and the hearing are related to temporal and spatial processes associated with communication mode, and sensory encoding modalities in short-term memory.

The hearing tend to use a speech-based code for short-term recall (Baddeley, 1966; Hintzmen, 1967; Conrad, 1962, 1964). Although the deaf can use phonetic or visual processes similar to the hearing (Hanson, 1982), they may also encode information through sign language parameters which are unique to the deaf (Bellugi et al., 1975, Poizner et al., 1981; Shand, 1982). American Sign Language uses visual space to convey meaning, and this may be related to the preference shown by deaf children for a spatial as opposed to a temporal orientation for ordered recall (Das, 1983; Hermelin & O'Connor, 1973; Karchmer et al., 1981).

A number of rehearsal strategies employed by the hearing have been used successfully to improve recall in the deaf (Bebko, 1984; Belmont et al., 1976; Liben & Drury, 1977). However, not all forms of rehearsal used by the hearing is directly beneficial for all deaf children. Vocalization rehearsal may be detrimental to deaf children who do not code information phonetically (Conrad, 1970, 1971), so it is important to design rehearsal strategies to meet the unique information processing style of the individual. Acoustic confusion errors have been used to evaluate the degree of

phonetic encoding used by deaf individuals (Conrad, 1972, 1973).

The deaf show memory deficits in comparison to the hearing in ordered recall tasks (Bellugi et al., 1975; Conrad, 1970; Hanson, 1982a; Macdougall, 1979; Wallace & Corballis, 1973). Ordered processes contribute to sequential flow of information in the English language, so they are particularly important for deaf children, who are at risk for language deficits (Krakow & Hanson, 1985).

Although a number of strategies have been used with the deaf, none has specifically been taught to improve performance in ordered recall tasks. A strategy which capitalizes on the natural spatial preference of deaf children may be effective for ordered recall. Although spatial rehearsal strategies are not common, deaf children have been observed spontaneously pointing in visual space, or touching the fingertips to indicate order in recall tasks (Bebko, 1984).

There is a need to investigate short-term recall strategies which will optimally use the sensory encoding methods available to deaf children who communicate through sign language. Therefore, this study addressed this need by comparing three sensory encoding strategies for ordered material with this group of children. The strategies included visualization, manual encoding, and a spatial encoding strategy. The spatial strategy was designed to take

advantage of the spatial preference shown by deaf children, and mimic the spontaneous spatial techniques which have been observed in this group.

Pictures and letter tasks were used to judge the effectiveness of strategies for materials which vary in imagery and familiarity. The present study also evaluated the degree and influence of phonetic processing through tabulation of acoustic confusion errors in letter recall.

CHAPTER III

The Problem

Statement of the Purpose

The main purpose of this study was to determine if three variations in strategy used for information encoding would result in significant differences in ordered or free recall for pictures or letters, in prelingually deaf children.

Rationale for Dependent and Independent Variables

Independent Variables

Task Materials. The materials which were chosen for the evaluation instruments included pictures and upper case manuscript letters. Both pictures and letters were used since ease of recall may vary with the material which is to be recalled. Deaf children have shown better recall for pictures than letters (Liben & Drury, 1977). A visualization, or imagery strategy may be used for picture recall, and if this was sufficiently effective, the additional information provided through manual or spatial encoding could be redundant, and the potential benefits of these two strategies would not be obvious.

Words were not chosen for the study because performance could be influenced both by familiarity with specific words, and reading level. Imagery strategies are also more easily

employed with words than letters. Although deaf adults recall orthographic (word-like) letter combinations better than unrelated letters (Hanson, 1982), non-word-like letter strings were chosen for this study because recall was less likely to be influenced by different language levels among the participants.

Since letters have been more poorly recalled than pictures, and do not appear to be recalled through a visualization process, manual and spatial encoding strategies which provide additional kinesthetic and visual spatial input could be relatively more useful with letter materials. The population of interest was deaf school children, who frequently have difficulty with English and spelling, so recall for letters and letter sequences has direct practical application to remedial techniques for this group. Upper case letters were chosen rather than lower case, since lower case letters are more difficult for young children with learning problems, such as letter reversals.

Encoding Strategies. Three encoding strategies for short-term ordered recall were compared, including visual, manual, and spatial. These strategies were compared in an effort to determine if improved encoding methods could assist ordered short-term recall.

In the visual condition, children viewed the stimulus material, but were not allowed to sign the name of the

picture or letter. The visual condition effectively acted as a control condition by eliminating manual kinesthetic input, but allowed other spontaneous strategies of the subject's choice, such as imagery or vocalization. The subjects were not required to vocalize, since there is some evidence that vocalization may interfere with recall in those subjects who do not use a phonetic processing method (Conrad, 1970, 1971b).

The manual strategy was chosen since it has been shown that manual encoding results in better short-term recall for deaf individuals who rely on the use of sign language (Stall & Marshall, 1984). The manual strategy allows all of the covert idiosyncratic strategies of the visual condition, but in addition provides additional proprioceptive and kinesthetic input through sign production as the materials are presented.

The spatial strategy was chosen since it is compatible with the spatial features of ASL used spontaneously by the deaf to express spatial relationships. Since the deaf appear to have difficulty with ordered recall (Krakow & Hanson, 1985), and deaf children have a preference for a spatial orientation (Karchmer et al., 1981; O'Connor & Hermelin, 1973), it is logical to attempt to capitalize on this preference to express order. The spatial strategy does this by asking the children to not only sign the material they see, thereby receiving kinesthetic input, but to sign the

series of items in order from left to right, capitalizing on visual space, and creating a mental location in space for each item. A sectioned cardboard strip was used in this strategy as a method to insure consistency in signing the order. As the child reached to each section of the strip and touched it, additional proprioceptive information was received as the entire arm moved through space.

Cumulative rehearsal was not encouraged in this study, since the main aim was to determine the effects of different sensory encoding methods, and cumulative rehearsal has already been shown to be effective in improving recall (Belmont et al., 1976; Bebko, 1984). However, children were not prevented from spontaneous use of cumulative rehearsal. Since, it would be impossible to prevent subvocalization cumulative rehearsal in the visual condition, the decision was made to also allow spontaneous manual cumulative rehearsal in the signing conditions.

Dependent Variables

Recall. Recall was used as the dependent variable since it plays a central role in learning, and through recalled material it is possible to determine the effectiveness of strategies to enter and retain information in memory. The subtests were scored for both free and ordered recall.

Ordered recall was measured since it indicated how well the children remembered the identity of the items, as well

as the order in which they were administered. Both requirements had to be met to obtain credit for a correct response. Ordered recall was considered to be important since ordered memory processes are required for many academic tasks, including spelling, mathematical operations, and reading.

Free recall was measured in addition to ordered recall to determine if superiority for a particular strategy was due to improved ability to put the stimulus items in the correct order, or whether it was also due to improved ability to recall the identity of the stimulus items. For the free recall scoring condition, items did not need to be in the correct serial position to obtain credit for a correct response.

Serial Position Scores. Serial Position scores were obtained for both the free and ordered recall scoring conditions. Analysis for primacy and recency patterns in serial position scores provides a basis to investigate possible rehearsal effects and short-term memory characteristics, leading to a better understanding of the phenomenon under investigation.

Phonetic Ratio. A phonetic ratio score was calculated comparing phonetic to nonphonetic confusion errors to determine the level of phonetic processing that children were using in the recall tasks. It was important to determine if this measure was correlated with overall

recall, since those who rely on a phonetic code may have less need for kinesthetic coding methods.

Interference Score. During administration of the tests, children frequently were unable to recall an item, but then recalled the item in the following sequence, where it was scored as an error. Because these "errors" really represented correct, although delayed recall, they were tabulated for the pictorial forms across the three encoding strategies, for further investigation in the data analysis.

Operational Definition of Terms

Cumulative Rehearsal: Repeated repetition of an item, plus the preceding items in a series, to assist recall.

Deafness: A degree of hearing impairment that precludes successful processing of linguistic information through audition, with or without a hearing aid (Berdine & Blackhurst, 1985, p. 192).

Encoding: The method by which information enters short-term memory through the sensory channels. The method chosen is a function of the stimulus material to be encoded, and the characteristics of the individual.

Free Recall Condition: The scoring condition in which credit is given for a correct response if the item matches one of the four items in the immediately preceding stimulus sequence, regardless of the serial position of the response.

Kinesthesia: The conscious awareness of joint position and movement (Ayres, 1974).

Manual Strategy: The strategy in which the child views the stimulus material for recall, and simultaneously signs the name of the picture or letter.

Prelingual Deafness: Deafness which develops before a child has developed speech and language.

Profound Hearing Loss: A hearing loss of 91 dB or greater (Heward & Orlansky, 1984, p. 235).

Proprioception: Unconscious information which arises from the muscles, joints, ligaments, and receptors associated with bones, which is used to regulate reflexes, automatic responses, and planned action (Ayres, 1974).

Rehearsal: Repetition or labelling of items to assist recall.

Ordered Recall Condition: The scoring condition in which credit is given for a correct response only if the response has the correct identity, and occupies the same serial position as the test presentation sequence.

Severe Hearing Loss: A 71-90 dB hearing loss (Heward & Orlansky, 1984, p. 235).

Spatial Strategy: The strategy in which the child views the stimulus material for recall, while simultaneously signing the name of the picture or letter, and pointing to a sectioned card in a sequential manner from left to

right.

Visual Strategy: The strategy in which the child views the stimulus material for recall, while maintaining the hands folded in front of the body.

Design

This study used a 2 (Task) X 3 (Strategy) X 4 (Serial Position) within-subjects experimental design. The task materials included letter strings or noun pictures, and the three strategies were visual, manual, and spatial.

Research Questions

The main questions asked by this study were:

Question 1: Will there be a difference in the total ordered recall scores of deaf children for picture or letter strings for three different encoding strategies?

Question 2: Will there be a difference in the total free recall scores of deaf children for picture or letter strings for three different encoding strategies?

Question 3: Will there be differential serial position effects (primacy and recency effects), for the picture and letter stimuli, and will these effects vary among the three strategies for the ordered scoring condition?

Question 4: Will there be differential serial position effects (primacy and recency effects), for the picture and letter stimuli, and will these effects vary among

the three strategies for the free scoring condition?

CHAPTER IV

Method

Subjects

The 36 subjects attended the Alberta School For The Deaf in Edmonton, Alberta. They were selected from the elementary program, and ranged in age from 6 years 11 months to 12 years 6 months. The sample consisted of 15 girls and 21 boys .

Since the goal was to study the recall of students who may use a visual-kinesthetic based, as opposed to a verbal-auditory based cognitive encoding system, all students who were included in the study showed prelingual hearing losses in the severe to profound range, and used sign language as the primary mode of communication. The unaided pure tone average of the group ranged from 70 to 120 dB, although only one student's hearing loss was less than 90 dB. Since hearing ability at the 2000 hz frequency is most important for processing of spoken information, both the aided and unaided hearing at 2000 hz was recorded. The presence or absence of a speech reception threshold was recorded for each child, since this measure is an indication that the child may actually hear speech, and therefore may be more likely to use speech-based information processing.

The etiology of the subjects' deafness included

heredity, meningitis, prenatal trauma and rubella, as well as unknown causes. Children were only excluded for medical reasons if they had a medical condition with known effects on memory, such as epilepsy or head injury; or took medication which could affect memory or alertness, such as Ritalin. Children with visual impairments were excluded only if they were unable to adequately see the stimulus materials.

Children were not excluded from the study on the basis of below average IQ if they were able to understand and complete the task demands. It was felt that the encoding strategies may also be important for children who were scoring below average on conventional IQ measures. Intellectual assessment measures were obtained from the student files. The childrens' IQ ranged from 71 to 128, based on scores obtained on the WISC-R Performance Scale or the Leiter International Performance Scale. Although these two measures do not provide identical scores, correlations between them range from .56 to .92, with a median correlation of .83 (Sattler, 1982, p. 251).

Of the available 41 children in the elementary program, 2 were excluded for medical reasons, 1 was excluded due to a hearing loss in the moderate range, and 2 were excluded because of an inability to cooperate with the task demands.

Apparatus

Evaluation Instruments

A brief pilot study was done with 3 subjects to determine the optimum length of the recall sequences. The number of items used for ordered recall sequences varies from 3 (Beck et al., 1977) to 8 (Bebko, 1984). In the pilot study it was apparent that even the older more competent students had so much difficulty remembering 5 items that there were few correct responses. Consequently, the tasks were constructed with 4 items, in order to avoid floor effects in the results. In the pilot study it was also determined that one practise sequence plus 16 test sequences in each form was the optimum length at which the maximum information was obtained, while still maintaining the child's attention and concentration. The optimum time for exposure of each item in a series was 3 seconds.

The instruments were constructed by making 3 forms of each of the letter and picture tests. Three forms for each of the two materials were constructed, and duplication of the sequences in different forms was avoided to control for practise effects, since the study used a within-subjects repeated measures design.

For the pictorial tests, pictures were selected from the Peabody Picture Vocabulary Test. The selected pictures could be represented by a sign which is commonly known to even young deaf students. Since the drawings are black and

white, there were no confounding effects due to stimulating colors. Pictures which fell in the same category, such as fruit or clothing were not grouped in the same sequence, since categorization may stimulate semantically assisted recall (Liben, 1979). Items whose sign representation showed identical hand configuration, movement pattern, or body location were also avoided in the same sequence due to possible confusion errors (Bellugi et al., 1975; Poizner et al., 1981; Shand, 1982).

The picture series were constructed by randomly selecting 4 items from the available pool of 75 pictures. Sixty-eight pictures were used for the practise and test items in each form. No picture was repeated in the same form.

Memory for letter strings which show acoustic similarities (i.e., T,P,V,G) in comparison to those which don't show acoustic similarities (i.e., X,Z,K,N,) has been used as a method to evaluate for use of phonetic vs nonphonetic encoding methods. Acoustic confusions may produce intrusion errors in recall with subjects who use verbal processing methods (Conrad, 1970; Belmont et al., 1976).

The letter sequences which were constructed for this study alternated strings from a pool of eight acoustically similar letters (B,C,D,P,T,G,E,V) and eight dissimilar letters (Z,K,X,N,M,W,Y,A). Although only consonant letters

have been used in a number of other studies to avoid word-like input, two vowels were used in the letter strings so that each of the eight letters in the two letter pools could be used only once in each of the four serial positions. Care was taken to avoid words or word-like strings. The practise sequences were constructed from letters which were in neither the similar or dissimilar groups.

Inadvertently, the rhyming letters K and A were included in the dissimilar group. Due to this error, scoring was modified from the method used by Conrad (1972) to include errors due to K,A acoustic confusions with the phonetic error group. The scoring method is outlined in the scoring section below. Because a different scoring method was used, the absolute values of the ratio were not compared to previous studies, but were instead investigated through correlational analysis with subject characteristics.

Equipment

All stimulus pictures and letters were mounted on 5 cm by 5 cm slides and projected at a blank wall at the subject's eye level. A kodak carousal slide projector equipped with a timer and automatic advance mechanism was used to present the slides. This method has been used successfully in previous studies (Das, 1983; McDaniel, 1980).

The pictures were initially reproduced on paper for identification in a recognition pretest (Appendix A). For the practise trials, the correct sequences were mounted on sectioned cardboard strips, starting from left to right, to provide visual confirmation of a correct response. A sectioned cardboard strip was used with the spatial encoding strategy.

Encoding Strategies

Visual Strategy

The visual strategy required the subject to sit with his hands folded in front of him as the slides were projected. The child was not allowed to sign the names of the slides. He was not prevented from vocalizing the names, but no specific directions were given to do so. Immediately following the appearance of a blank slide following the fourth item, the subject signed to the examiner the names of the four letters or pictures that he had seen in the same order as the presentation.

Manual Strategy

The manual strategy required the subject to sign the names of the pictures as they were presented. Again the subject was allowed to vocalize if he wished, but was not instructed to do so.

Spatial Strategy

The spatial strategy also required the child to sign the names of the letters or pictures as the slides were projected, however the child was also required to point to the corresponding location on a sectioned stimulus card placed in front of him, starting from left to right. The stimulus card was used to ensure that the child actually pointed out the sequence in order during the stimulus presentation. The child was allowed to use the stimulus card to indicate his response order, since this also made use of the spatial strategy.

Procedure

Each child was tested individually at the Alberta School for the Deaf, in a quiet area free from distractions by other children. In the first session, the child was seated at a table facing a blank wall aproximately five feet away. He was initially required to identify all of the stimulus pictures. If a child used a consistent, although incorrect sign for a particular picture (ie dress for skirt) or letter, it was accepted if the response sign could not be confused with any of the other stimulus items. Since all of the children knew their upper case letters, no letter pretest was given.

Each subject completed the recall tasks under three encoding conditions, including visual, manual and spatial.

Half the children were randomly selected to receive letters first, while the other half received pictures first. Similarly, strategy order was balanced. The children were divided into thirds and randomly assigned the three strategies, so equal numbers received each strategy first, second or third.

The first two of the total six subtests were administered immediately following the identification of the stimulus items. The remaining four subtests were administered in groups of two (letter and picture) for the remaining two strategies. Each child was tested in three separate sessions to control for fatigue effects. The interval between test sessions ranged from one day to one week, although most children were tested on a regular schedule on Monday, Wednesday and Friday. Test order of the materials was alternated, so if a child started with letters in the first session, he began with pictures in the second, and letters again in the third.

Each form was administered in the same manner. The particular strategy which was required was explained and demonstrated to the child by the examiner. During the practise trial, the child learned the strategy. The examiner requested the child to recall the items in the same sequence in which they were presented. To emphasize this point, a demonstration response card was used for each practise trial with the correct picture or letter sequence shown from left

to right. The practise trial was attempted repeatedly until the child fully understood the input strategy and response requirements, and attained a perfect response which matched the demonstration card. Standard signed and spoken directions were given to each subject (Appendix B), although these were modified when necessary to ensure that the subject understood the task requirements.

In each case, the test began with a blank slide to alert the child that the test was beginning. Each slide was shown for 3 seconds, followed immediately by the next slide. The child was allowed to respond immediately after a blank slide appeared following the last item in the sequence of four. Each subsequent sequence again began with a blank slide.

Although it was initially planned that children write their responses on paper, during the pilot study it was apparent that this created such differences in response times that an immediate signed response was preferable, despite the possible effect on recording reliability. In addition, few children were able to write the names of the pictures, so allowing written responses would create a difference in methodology among subjects, which could produce differences due to testing effects. For these reasons, all children were required to give an immediate signed response at the end of each sequence.

Recording

The responses were recorded in the serial positions, in the same order as the child's temporal response unless he indicated otherwise. For example, the first response would be placed under serial position 1 unless the child clearly indicated that it was in another position by signing (ie LAST...X), or by showing the position using ASL (ie with 4 fingers extended, indicate the letter X was second by pointing to the middle finger). The children were not prompted in their responses by asking which was first, second, etc.

Scoring

Ordered and Free Recall Scoring Conditions

The response sheets were scored for both ordered and free recall. In the ordered condition, credit was given for a correct response only if the response matched the stimulus picture or letter for that serial position. In the free condition, scoring was more liberal, with credit being given for all responses that matched any of the four stimulus items in the sequence, regardless of the serial position.

A correct response received a score of 1, and an incorrect response received a score of 0. Total scores, as well as scores for each serial position were calculated for both the free and ordered scoring conditions. Each of the four serial positions had a possible score of 15, with a

total possible score of 64 for each form in both the free and ordered scoring conditions.

Phonetic Ratio

A phonetic ratio was calculated using the ordered recall scores from the acoustically similar and dissimilar letter sequences. To obtain the ratio, the total errors in each letter subtest was calculated. The blank spaces, or errors of omission were then subtracted from this total, since omission errors would not clearly indicate any particular type of confusion error. Of the remaining errors, each was examined, and incorrect responses that rhymed with required responses were totalled, as were the nonrhyming errors. The totals were then used to compute the ratio; with the total phonetic errors divided by the total nonphonetic errors.

Interference Score

Interference errors were those responses on the pictorial forms which represented delayed correct responses. They were responses which were not recalled following the initial stimulus sequence, but were then incorrectly recalled following the next stimulus sequence. A total interference score was tabulated for the three picture forms, across the three input strategies.

CHAPTER V

Results and Discussion

The results of the study were first compared for total recall scores using a 3 X 2 (Strategy X Task) analysis of variance with repeated measures on all factors, for both the free and ordered recall scoring conditions. The serial position effects were then considered separately, again in relation to both free and ordered recall using a 4 X 3 X 2 (Serial Position X Strategy X Task) analysis of variance with repeated measures on all factors. Correlations among sex, IQ, interference effects, phonetic ratio, speech reception threshold, and audiological measures were calculated using the Pearson Product Moment Correlation. For all data analysis, the significance level for the rejection of the null hypothesis was set at an alpha level of .05. Scheffe post hoc tests were used for all comparisons of means following the analysis of variance procedures.

The total recall task by strategy results will be reported and discussed first, followed by the serial position effects. Finally, the correlational results will be reported and discussed.

Strategy and Task Effects

The free recall scoring condition measured short-term

recall without the requirement for an ordered response. The 3 X 2 analysis of variance for free recall revealed significant main effects for task material, F (1,35) = 10.618, $p<.002$; and strategy, F (2,70) = 16.430, $p<.001$, although there was not a significant task by strategy interaction. The free recall 2 X 3 ANOVA is depicted graphically in Figure 1, and the means and standard deviations are presented in Table 1. The ANOVA data is reported in Table C-1.

The main effect for task indicated higher overall scores for letters in free recall. Scheffe post hoc tests were used to investigate the main effect for strategy, which indicated that the mean recall for the visual strategy was significantly lower than the manual and spatial strategies. Differences between the manual and spatial strategies were nonsignificant.

Both the manual and visual strategies showed significantly better recall for letters than pictures in free recall. However, although the trend for the spatial strategy was also in this direction, the difference between picture and letter recall was nonsignificant.

For the free recall situation, there was an almost identical pattern of recall for the three strategies, and two tasks, with the visual strategy being lower. The manual and spatial strategies showed almost identical scores for both letters and pictures (Figure 1, Table 1). When

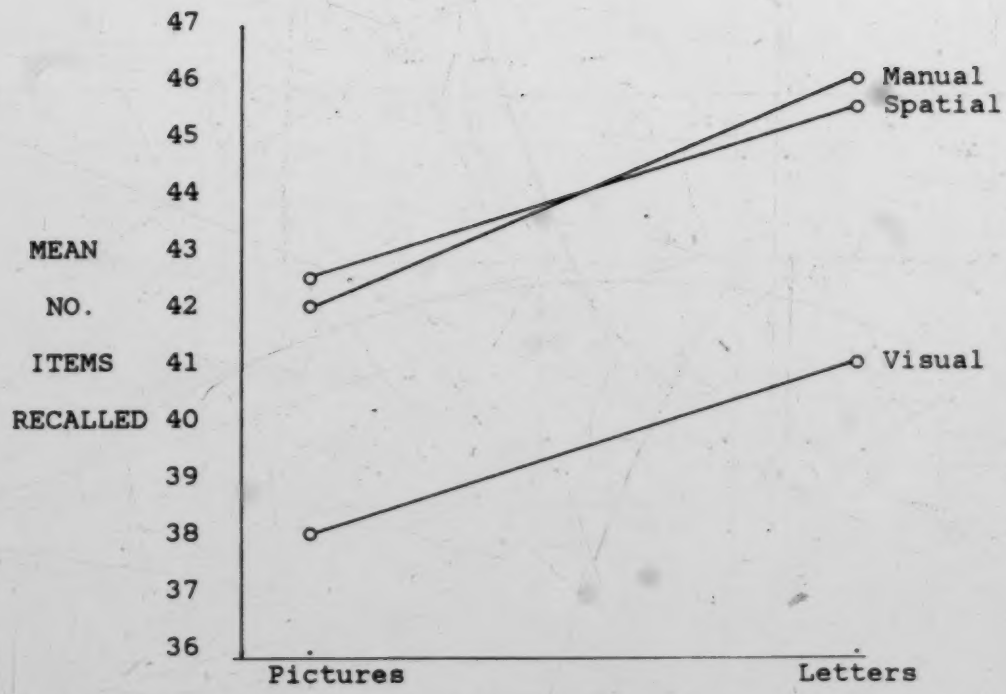

Figure 1. The mean short-term free recall for three encoding strategies and two task materials.

(N = 36)

Table 1

Means and Standard Deviations for Free Recall Data for Three Strategies and Two Tasks

	Pictures		Letters	
Strategy	M	SD	M	SD
Visual	37.89	8.57	41.44	11.25
Manual	42.00	9.92	45.94	10.74
Spatial	42.44	7.48	45.69	9.88

(N = 36)

compared to the manual strategy, it can be concluded that the spatial strategy didn't improve free recall ability, nor did it interfere with the recall process.

Proprioceptive and kinesthetic input was common to both the manual and spatial strategies, but absent from the visual strategy. One hypothesis for the superiority of the manual/spatial strategies is that processing of the kinesthetic and proprioceptive input received while signing the items to be recalled resulted in more effective processing, or a stronger short-term memory trace. The benefits of proprioceptive and kinesthetic encoding for the deaf lend support to those who propose that the deaf who rely on the use of sign language are using an alternate information processing system based on these parameters. (Karchmer et al., 1981; Stall & Marshall, 1984; Tomlinson-Keasey & Kelly, 1978).

An alternate hypothesis is that the signing advantage was simply due to no rehearsal in the visual strategy versus rehearsal in the manual and spatial strategies. However, it must be remembered that the children were free to use the normal hearing strategy of vocalization if they wished for the visual strategy. The visual strategy only prevented them from signing, which should be a strategy that would be uniquely valuable for the signing deaf. Despite the freedom to use a vocalization strategy, only 5 out of the total 36 children spontaneously vocalized during the visual

condition. An objective method of investigating the nature of the difference between the visual, manual and spatial strategies is through examination of serial position effects in the following section.

Although the spatial strategy had no impact on total free recall in comparison to the manual strategy, it did show important effects in the ordered scoring condition. The ordered condition required recall, as well as correct response order, and produced somewhat different results for the 2 X 3 ANOVA (Table C-2). Significant main effects were found for task, F (1,35) = 13.460, $p<.001$; and strategy, F (2,70) = 27.413, $p<.001$. A significant task by strategy interaction, F (2,70) = 9.096, $p<.001$ was also found. The ordinal interaction is depicted graphically in Figure 2. The means and standard deviations are listed in Table 2.

Scheffe comparisons of means indicated that for the pictorial tasks, the spatial strategy showed significantly higher ordered recall than the manual or visual strategies. Although there was a trend favoring the manual strategy over the visual, the difference between the visual and manual strategies was nonsignificant for ordered recall of pictures (Figure 2).

For ordered recall of letters, the manual and spatial strategies were both significantly higher than the visual strategy. A trend favoured the spatial strategy over the manual, however the difference between the manual and

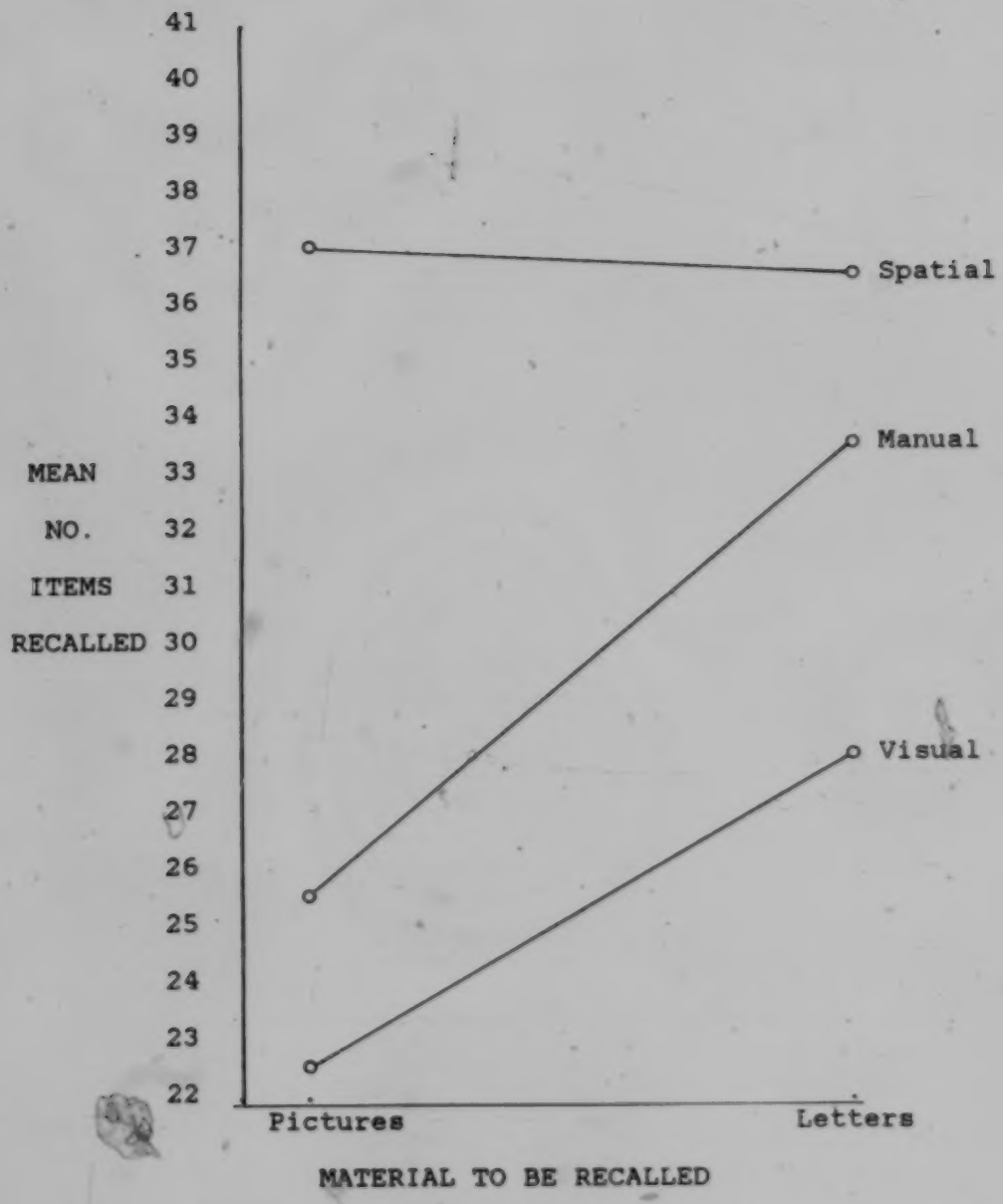

Figure 2. The mean short-term ordered recall for three encoding strategies and two task materials. (N = 36)

Table 2

Means and Standard Deviations for Ordered Recall Data for Three Strategies and Two Tasks

	Pictures		Letters	
Strategy	M	SD	M	SD
Visual	22.58	12.13	28.33	14.95
Manual	25.75	16.01	33.78	16.51
Spatial	36.97	9.86	36.75	13.25

(N = 36)

spatial strategies was nonsignificant (Figure 2).

The visual and manual strategies both produced significantly better ordered recall for letters than pictures, however there was no difference between pictures and letters for the spatial strategy. Although results for the spatial strategy resemble a ceiling effect, this was not an effect imposed by test limits, since the mean recall of 37 for the spatial strategy was in relation to a possible score of 64. The lack of difference between pictures and letters for ordered recall and the spatial strategy may have been related to internal maturational, attentional or cognitive factors which acted to limit the recall of this group of deaf children. Perhaps the spatial strategy maximized performance within the limits imposed by these other variables.

Both the free and ordered recall scoring conditions showed a main effect for task, with recall for letters higher than pictures. This result is somewhat inconsistent with a previous study by Liben and Drury (1977) which found better ordered recall for pictures of familiar animals than lowercase letters. Closer examination of Liben and Drury's study showed that each of the animal and letter stimuli pools contained six items. Since all the items became very familiar through constant repetition, this may suggest the reason for the discrepancy with the present study. In the present study, the pool of 75 pictures showed no repetition

in each form, so the pictures were more unfamiliar to the children. However, the capital letters used a pool of only 16 letters, which were already familiar to the children. Deaf children also receive practice in manual rehearsal with letters through spelling practise, and may already use more sophisticated rehearsal strategies with letters, such as "chunking". This familiarity with the material may have resulted in generally better recall for letters across strategies.

The spatial strategy showed an obvious advantage over the other two strategies for ordered recall of pictures. One possible explanation is that the need to retain the unfamiliar pictures in memory, plus remember the presentation order, may have placed more stress on the children. Because of this, there were relatively greater benefits from the additional information provided by the spatial strategy to recall the order of the picture stimuli. It is possible that in the classroom situation, when stress is being placed on the children for speed and accuracy in such ordered recall tasks such as spelling, that the spatial strategy would be more beneficial than simple manual rehearsal, despite the nonsignificant differences for letters in the present study.

The method by which the spatial strategy improves recall for order merits examination. One hypothesis is that the additional proprioceptive and visual sensory input when

reaching to point in order creates a response cue for the item in visual space.

A second possibility is that the cardboard strip used in the spatial strategy allowed the child to respond in any temporal order he wished, and use the pointing response on the card to "sort" his response into an ordered correct response. This second explanation would imply that the spatial strategy acts to organize output rather than input. Most of the children showed delayed language development and may have lacked adequate language to explain order. Since several children did show the "sorting" strategy described above, the second explanation may have merit. It is also possible that the effect was due to a combination of these two possibilities. Both explanations are compatible with the finding that deaf chidren show a spatial rather than a temporal preference (Beck et al., 1977; Conrad & Freeman, 1975; Hermelin & O'Connor, 1973; Karchmer et al., 1981).

Summary

The overall conclusion from this discussion is that the manual and spatial encoding strategies were equally superior to the visual strategy for free recall. The specific function of the spatial strategy in comparison to the manual strategy was to improve order of recall rather than to improve the total number of items recalled, particularly for less familiar pictorial material. Investigation of the

serial position effects may help reveal processes being used in the three recall strategies.

Serial Position Effects

Free Recall and Serial Position Effects

The serial position effects for free recall are most easily interpreted, since the pattern of which items were recalled is not confused with response order.

The serial position effects for free recall were analyzed using a 4 X 3 X 2 (Serial Position X Strategy X Task) analysis of variance with repeated measures on all factors (Table C-3). Main effects were present for task, F (1,35) = 11.541, $p<.002$; and strategy, F (2,70) = 15.672, $p<.001$. The main effects from the three-way ANOVA agree with the results from the two-way ANOVA reported above.

There was a main effect for position, F (3,105) = 8.227, $p<.001$. Scheffe post hoc tests of the main effect for position revealed that position 1 and 4 were equivalent. Recall was greater in these two positions than for position 2 and 3 which were also equivalent, indicating a primacy and recency effect on position 1 and 4, for free recall.

There was not a significant strategy by position interaction, however there was a significant task by position interaction, F (3,105) = 8.2444, $p<.001$; and a significant three-way (Position X Strategy X Task) interaction, F (6,210) = 2.314, $p<.035$. Graphs of the serial

position by strategy for free recall are presented separately for the two task materials in Figure 3 (pictures) and Figure 4 (letters), with the list of means and standard deviations in Table 3 (pictures) and Table 4 (letters).

Although there was a main effect for position with clear primacy and recency effects, the results are not as clear when the picture and letter tasks are analyzed separately. Most differences between cell means in the serial positions for pictures and letters were statistically nonsignificant. However, patterns emerged which merit examination, to help clarify the recall processes being used by the children in this study. If the sample was larger, these trends may have reached statistical significance.

For free recall picture tasks, the only significant differences were between the spatial strategy for position 4 and the visual strategy for position 2, although the trend in the results suggested both primacy and recency effects on position 1 and 4 for the three strategies. The primacy effect on position 1 was almost identical for all three strategies (Figure 3).

For free recall letter tasks, statistically significant differences were found only between the spatial strategy for position 1 and the visual strategy for position 3. Graphically the trend toward a primacy effect is apparent for the manual and spatial strategies. A recency effect is most apparent for the manual strategy on position 4 (Figure

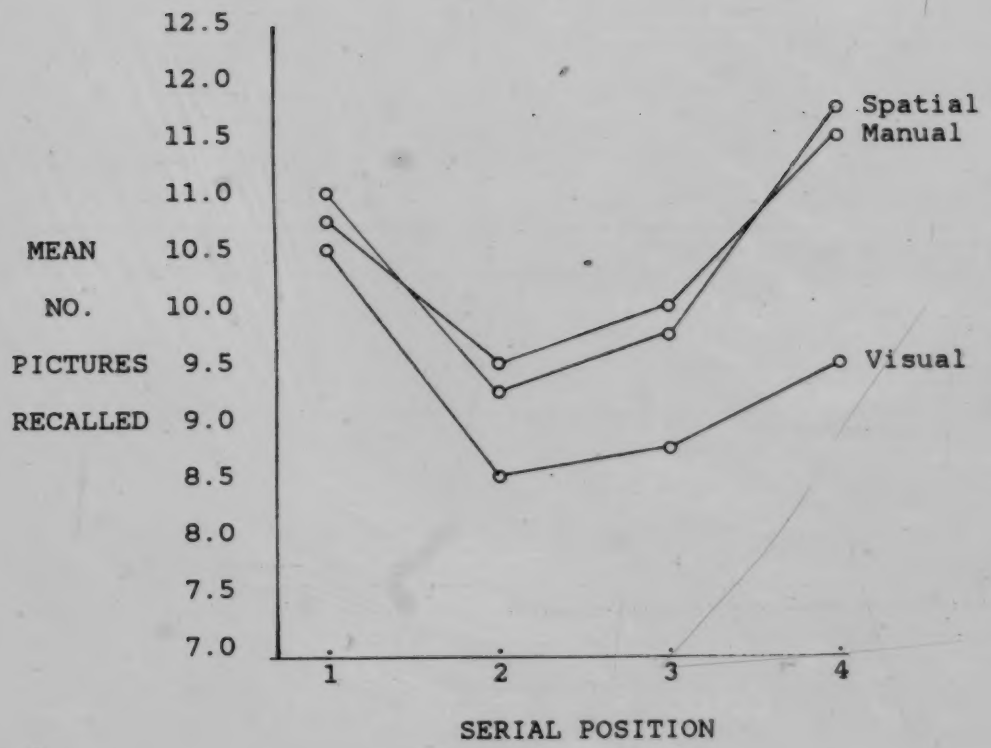

Figure 3. The mean short-term free recall for three encoding strategies and four serial positions, for pictures. (N = 36)

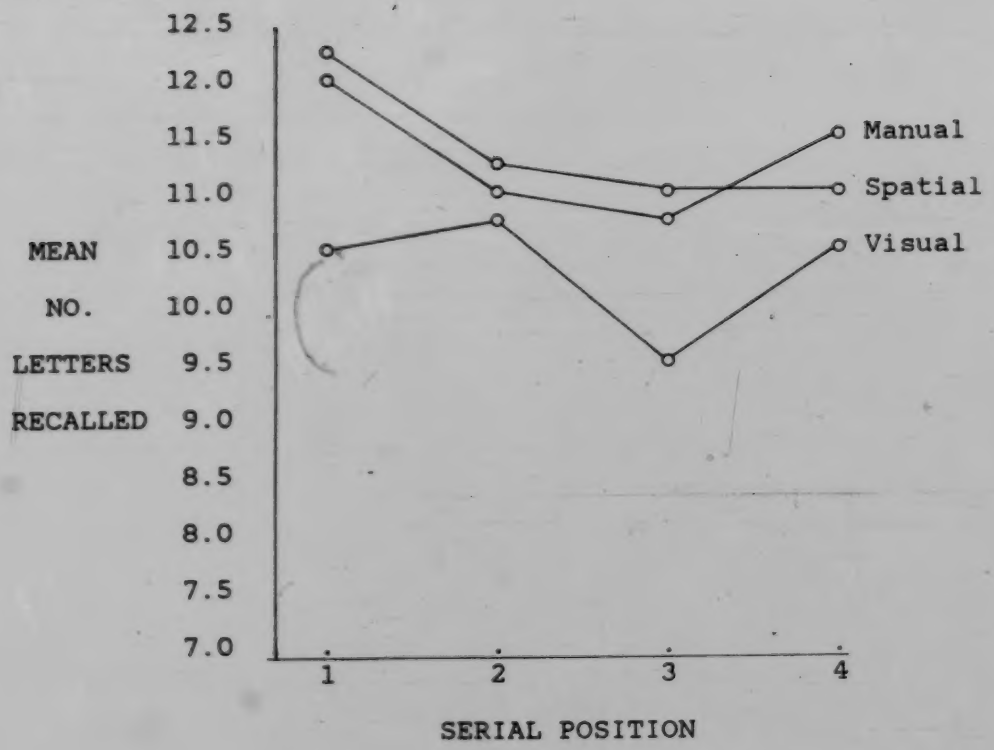

Figure 4. The mean short-term free recall for three encoding strategies and four serial positions, for letters. (N = 36)

Table 3

Means and Standard Deviations of Serial Positions for Pictures in Free Recall

	Serial Position							
	1		2		3		4	
Strategy	M	SD	M	SD	M	SD	M	SD
Visual	10.50	3.21	8.72	3.23	8.89	2.68	9.72	2.87
Manual	10.92	3.40	9.50	3.39	10.06	2.87	11.53	2.83
Spatial	11.14	2.57	9.42	3.33	9.89	2.41	11.97	2.49

(N = 36)

Table 4

Means and Standard Deviations of Serial Positions for Letters in Free Recall

	Serial Position							
	1		2		3		4	
Strategy	M	SD	M	SD	M	SD	M	SD
Visual	10.58	3.48	10.81	3.62	9.64	3.67	10.69	2.95
Manual	12.17	3.38	11.36	3.42	10.81	3.34	11.61	2.84
Spatial	12.19	2.76	11.42	2.94	11.00	2.99	11.08	2.97

(N = 36)

4). Again these results may have reached significance with a larger sample.

Several interpretations of primacy effects have been suggested. As discussed in the review of the literature, according to the buffer model of memory, the middle and primacy portions of the curve reflect retrieval of information from the long-term store. Another aspect of this theory is that the primacy effect reflects rehearsal in short-term memory (Atkinson & Shiffrin, 1971).

Primacy effects have been found in deaf children following ordered learning tasks for stimuli including pictures, nonsense shapes, print and letter handshapes when labelling and gesturing was allowed during stimulus presentation (Liben, 1984). The findings of primacy effects for the pictures and letters in the manual and spatial strategies in the present study is consistent with Liben's (1984) findings.

However, a primacy effect also existed for the visual condition in this study, despite little or no obvious verbal rehearsal from most children during the visual condition. Other researchers have found a similar primacy effect without obvious rehearsal (Swanson,1982). Swanson's explanation was that since the objects to be recalled had a meaningful name, the children used this to create semantic codes to assist recall. This does not adequately explain why the first items in the series should be remembered better,

since all items in the series would have the benefit of semantic processing.

Liben and Drury (1977) also found primacy effects for nonsense forms which were not readily labelled. Their hypothesis was that the children were using a form of covert verbal rehearsal or visual imaginal rehearsal. If this hypothesis was accepted, it would refute the argument that the advantage of the manual and spatial strategies was simply due to "some rehearsal" versus "no rehearsal" in the visual condition.

Liben and Drury (1977) suggested that the primacy effect may also have been due to a process other than rehearsal; that is greater attention was paid to the earlier items in the list. Both of these explanations provide plausible reasons for the apppearance of the primacy effect for the visual strategy with pictures in the present study.

As discussed in the review of the literature, recency effects may represent retrieval from the short-term memory buffer (Atkinson & Shiffrin, 1977). Another point made by Bourne et al. (1986) is that recency effects may be due to an output order strategy in which the subjects report the items from the last part of the list first, while they are still in the short-term memory. Due to "output interference" as more items are reported, some of the ones that are not yet reported are forgotton. Some, although not all of the children in this study showed the response

pattern described above, despite a request for an ordered response.

A recency effect was present for all three strategies on position 4, for free recall of pictures. However, the visual strategy was lower than the manual and spatial strategies which were again almost identical. For children who spontaneously reported the last item first, similar processes may have been used for all three strategies. However, for those who were able to respond correctly in order, perhaps the superior recall of the manual and spatial strategies was due to a stronger image created by the kinesthetic input of the signing strategy which stayed in the short-term memory buffer longer, and was more easily retrieved.

The letter task did not show the same clear pattern of primacy and recency effects for all strategies (Figure 4). The manual and spatial strategies maintained a primacy effect, with scores across the first three letter positions being relatively higher than their equivalent positions in the picture tasks. However, the letter score for position 4 was almost identical to the picture score for the manual and spatial strategies, indicating that the differential effect for task was due to greater improvement in the primacy portions of the letter curve for the manual and spatial strategies (see Table 3 and 4).

In contrast to the manual and spatial strategies, the

visual strategy showed higher recall for letters than pictures on the last three positions, as opposed to the first three, while the visual picture and letter scores for position 1 were almost identical. The difference between pictures and letters for the visual strategy affected more the recency portions of the curve.

One explanation for the differential effects due to task for the different strategies may be related to the characteristics of the encoding methods used for the strategies, which interacted with the task. If a visualization method was being used for both pictures and letters in the visual strategy, this may have resulted in similar primacy scores for pictures and letters. The higher recency effects for visual letters could be attributed to the more familiar letters being held more easily in the short-term memory buffer.

The relatively higher primacy effects for the manual and spatial strategies must be related in some way to the redundancy of the sign image for pictures and letters. The signs for the pictures had active movement patterns and varied in sign location: for example, the sign for cat strokes the face as if to show whiskers, while the sign for dog taps the thigh with the flat hand. In contrast, most letter signs have no movement pattern (with the exception of j and z) and the location of all letter signs is in a neutral plane in front of the body. However, each letter

uses a distinctive static handshape which could be held thorough the entire 3 seconds while the stimulus slide was being shown. Perhaps the static handshape of the letters produced a stronger kinesthetic image which resulted in stronger primacy effects for manual and spatial letters.

As suggested previously, the slight drop in the recency effect for letters could have appeared due to the time that the child took to respond with primacy items in the letter task, since during that time they may have lost some of the last items from the short-term memory buffer.

Ordered Recall and Serial Position Effects

Serial position effects are not generally examined in relation to ordered recall tasks, however analysis of the graphs in Figure 5 (pictures) and Figure 6 (letters) provides useful information regarding the ordered response patterns for the strategies and tasks.

The results of the three-way analysis of variance (Position X Strategy X Task) for ordered recall were somewhat clearer than for free recall. Main effects were present for position, F (3,105) = 104.177, $p<.001$; Strategy, F (2,70) = 27.706, $p<.001$; and Task, F (1,35) = 13.200, $p<.001$. The main effects for strategy and task were in agreement with the two-way ANOVA reported initially.

Scheffe post hoc tests for the position main effect indicated that the mean recall in position 1 was higher

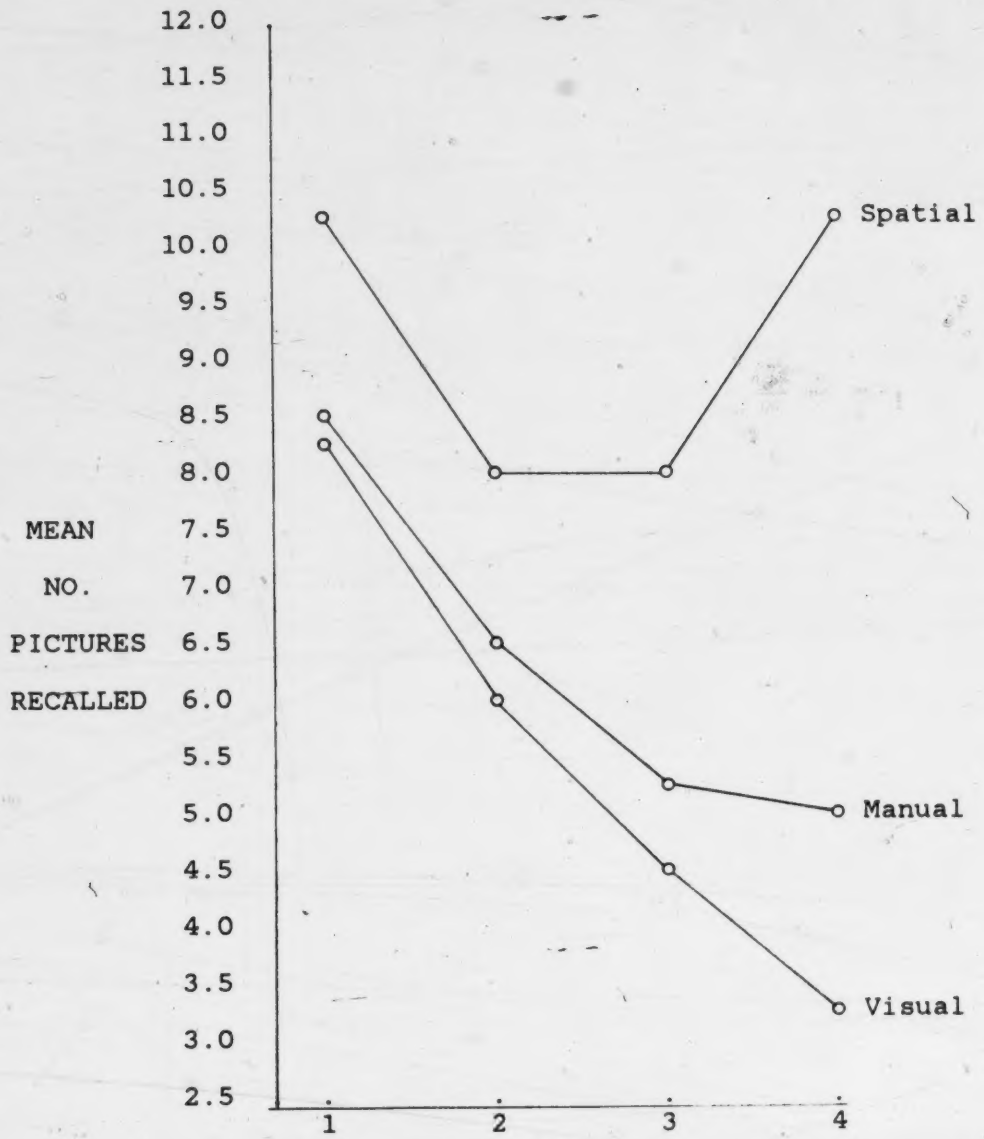

Figure 5. The mean short-term ordered recall for three encoding strategies and four serial positions, for pictures. (N = 36)

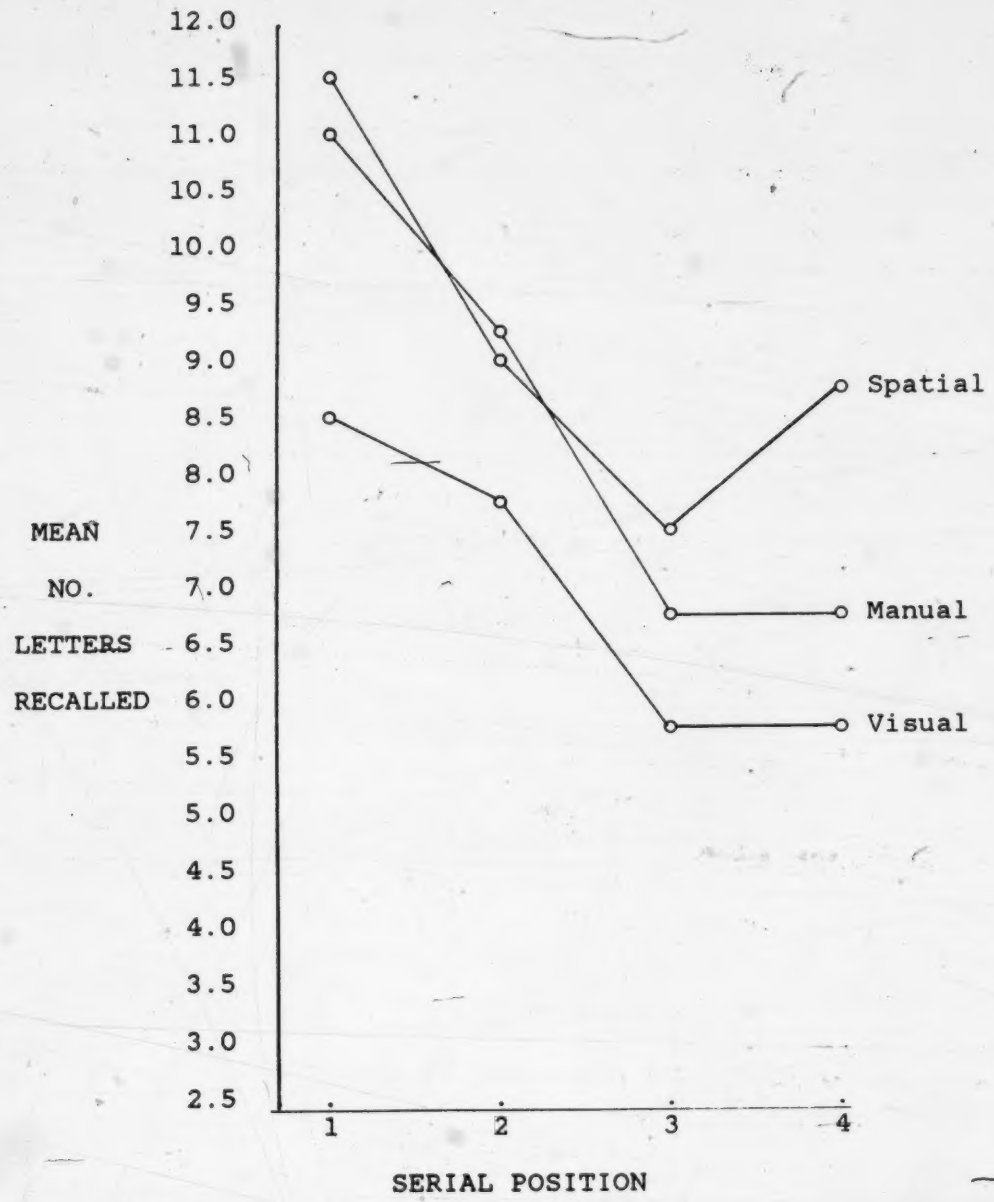

Figure 6. The mean short-term ordered recall for three encoding strategies and four serial positions, for letters. (N = 36)

than any other position. Position 2 showed higher recall than position 3 and 4, which showed nonsignificant differences.

All two-way interactions were significant, including the task by strategy interaction, F (2,70) = 8.971, $p<.001$; the task by position interaction, F (3,105) = 3.487, $p<.018$; and the strategy by position interaction, F (6,210) = 13.353, $p<.001$. The interpretation of the interactions will be made with respect to the three-way (Position X Strategy X Task) interaction which was also significant, F (6,210) = 5.480, $p<.001$. The ordered recall three-way ANOVA is reported in Table C-4, and the cell means amd standard deviations are presented in Table 5 (pictures) and Table 6 (letters). For ease of interpretation, the three-way ANOVA is graphed separately as two two-way (Position X Strategy) interactions varying the task materials, in Figure 5 (pictures) and Figure 6 (letters).

For the spatial strategy with pictures, position 1 and 4 showed nonsignificant differences. Differences between position 2 and 4 were also nonsignificant. However, position 2 and 3 showed poorer recall than position 1 and 4, suggesting both primacy and recency effects for the spatial strategy in ordered recall (Figure 5). The primacy and recency effects of the spatial strategy for both free and ordered recall indicated that not only did children remember more of the items in position 1 and 4 in free recall, but

Table 5

Means and Standard Deviations of Serial Positions for Pictures in Ordered Recall

	Serial Position							
	1		2		3		4	
Strategy	M	SD	M	SD	M	SD	M	SD
Visual	8.33	4.30	6.25	3.20	4.56	2.93	3.47	2.99
Manual	8.58	4.40	6.83	4.09	5.25	4.07	5.08	4.31
Spatial	10.44	2.97	8.06	3.46	8.00	3.03	10.47	3.19

(N = 36)

Table 6

Means and Standard Deviations of Serial Positions for Letters in Ordered Recall

	Serial Position							
	1		2		3		4	
Strategy	M	SD	M	SD	M	SD	M	SD
Visual	8.69	4.22	7.94	3.99	5.81	4.17	5.89	3.88
Manual	10.69	4.13	9.28	4.12	6.78	4.49	6.94	4.78
Spatial	11.03	3.39	9.19	3.52	7.64	3.86	8.89	3.86

(N = 36)

they also remembered the serial position of these items. It is important to note that for the spatial strategy some children responded with the output strategy described earlier, with the most recent items first, but they used the spatial strategy card to correctly indicate the temporal order. In this way children achieved a correct ordered response for an item despite responding in a confused temporal order. This may explain the pronounced recency effect for spatial pictures.

For the spatial strategy with letters, differences were nonsignificant for positions 1, 2, and 4. Differences between positions 2, 3, and 4 were also nonsignificant. The only difference which reached significance indicated greater recall in position 1 than position 3. Although the differences were nonsignificant, the trend was toward a primacy effect for the spatial strategy on position 1 (Figure 6). For the spatial strategy with letters, the primacy effect was stronger and the recency effect weaker than with pictures (Figure 5). This represents a similar pattern which was demonstrated in the free recall condition. The previous explanation regarding the redundancy of the picture and letter signs may also apply in this situation.

For pictures, using the visual strategy, there appeared to be a gradual disintegration of the primacy effect. Recall in position 1 was greater than in position 3 and 4, although not significantly greater than position 2. Similarly, recall

in position 2 was greater than position 4, although not significantly greater than position 3. Position 3 and 4 were not significantly different.

For letters, using the visual strategy, a clearer primacy effect emerged for position 1 and 2. Again, position 1 and 2 were equivalent, with position 1 showing greater recall than position 3 or 4, however position 2, 3, and 4 were not significantly different.

For the manual strategy, a primacy pattern similar to the visual strategy emerged. For picture recall, position 1 and 2 were equivalent, although position 1 showed better recall than position 3 or 4. Differences between position 2, 3, and 4 were nonsignificant.

For letter recall using the manual strategy, position 1 and 2 again showed no significant differences, and position 1 showed higher recall than position 3 or 4. Position 2 showed higher recall than position 3, however the differences between position 2 and 4; and 3 and 4, were nonsignificant.

For the manual and visual condition, similar patterns were apparent for both pictures and letters in ordered recall, although the absolute values for the manual strategy were higher. Although most of the differences between adjacent means did not reach statistical significance, the trend showed a gradual decline in accuracy from position 1 to 4, which is apparent in Figure 5 and 6. As in the spatial

strategy, there was a strong tendency to remember both the identity and the location of the first items in the manual and visual conditions.

The scoring method may have contributed to the pattern produced for the ordered manual and visual strategies, particularly with regard to the loss of the recency effect. In the strict scoring criteria for the ordered condition, if a child forgot items and gave 2 or 3 items instead of 4, the last item was placed in serial position 2 or 3. This may have resulted in a number of items correctly recalled as the "last" item being placed in the wrong serial position, unless the child specifically instructed that an item was the fourth one in some way. Similarly, if a child responded first with a recency item, it was considered incorrect unless the child indicated it's correct serial position in some way. Children were much less likely to indicate a specific position without the use of the spatial card. However, some children who had already experienced the spatial strategy generalized the response strategy to the manual or visual situation and organized their response order by pointing to specific fingers, or to imaginary spaces on the table, mimicking the spatial card.

Summary

In terms of an overall impression with respect to serial position effects, free recall showed a trend to both primacy

and recency effects, with the spatial and manual stategies showing the clearest results for pictorial materials. In contrast, ordered recall maintained a trend toward the primacy effect across strategies, although many of the differences were not significant. Only the spatial strategy retained the trend toward a recency effect on position 4 for ordered recall.

The investigation of serial position effects in free and ordered recall has led to some speculative, although plausible explanations regarding the role of organization of temporal and spatial responses, strength of proprioceptive as opposed to visual images, and essential differences between signs for letters and pictures which may have contributed to differing image strengths for primacy and recency effects.

Correlational Analysis

Correlational analysis was performed to investigate the relationships between various subject characteristics, and recall performance. It was also used to determine the interrelationships among the tasks and measures which were used. Pearson Product Moment Correlations were calculated among the variables of age, sex, IQ, audiological data, phonetic ratio, and interference effects with both the free and ordered recall subtest scores. These correlations are presented in Table 7. Intercorrelations among the subtests are presented in Table 8.

Table 7

Correlations Among IQ, Aided and Unaided Hearing at 2000 hz Age, Sex, Speech Reception Threshold, Phonetic Ratio, Interference Score and Recall Scores

	Age	Sex	IQ	A2HZ	UA2HZ	SRT	PR	IS
IQ	-.49	*	1.00	*	.30	*	.42	-.42
SRT	*	*	*	-.50	-.62	1.00	.32	*
IS	*	-.52	-.42	.26	*	*	-.35	1.00
OSPIC	.40	.30	*	-.28	*	.34	.31	-.30
OSLET	*	.32	*	-.32	-.28	.43	.48	-.36
OMPIC	*	.38	*	*	*	*	.47	-.42
OMLET	*	.37	*	-.30	*	*	.42	-.46
OVPIC	.39	*	*	-.47	-.29	.29	.31	-.47
OVLET	*	.32	*	*	*	.32	.52	-.45
FSPIC	.45	.28	*	*	*	.37	.28	-.42
FSLET	.32	.36	*	-.32	*	.39	.50	-.46
FMPIC	*	.44	*	*	*	*	.42	-.43
FMLET	*	*	*	*	*	*	.45	-.40
FVPIC	.56	*	*	-.44	-.31	*	*	-.29
FVLET	.29	.31	*	*	*	.32	.48	-.42

Note. * = nonsignificant correlation

A2HZ = aided hearing at 2000 hz
UA2HZ = unaided hearing at 2000 hz
SRT = speech reception threshold
PR = phonetic ratio
IS = interference score

PIC= pictures
OSPIC = ordered spatial pic
OMPIC = ordered manual pic
OVPIC = ordered visual pic
FSPIC = free spatial pic
FMPIC = free manual pic
FVPIC = free visual pic

LET = letters
OSLET = ordered spatial let
OMLET = ordered manual let
OVLET = ordered visual let
FSLET = free spatial let
FMLET = free manual let
FVLET = free visual let

For all correlations $p < .05$ (one-tailed test).

Table 8

Intercorrelations Among Free and Ordered Recall Scores

	OSP	OSL	OMP	OML	OVP	OVL	FSP	FSL	FMP	FML	FVP	FVL
OSP	1	.57	.60	.67	.63	.57	.86	.54	.62	.59	.67	.54
OSL	.57	1	.55	.66	.57	.82	.57	.92	.45	.71	.51	.80
OMP	.60	.55	1	.82	.62	.69	.58	.52	.68	.74	.43	.58
OML	.67	.66	.82	1	.72	.84	.67	.70	.68	.93	.64	.80
OVP	.63	.57	.62	.72	1	.77	.56	.61	.40	.67	.75	.69
OVL	.57	.82	.69	.84	.77	1	.59	.85	.53	.88	.64	.94
FSP	.86	.57	.58	.67	.56	.59	1	.64	.74	.65	.73	.61
FSL	.54	.92	.52	.70	.61	.85	.64	1	.53	.77	.63	.88
FMP	.62	.45	.68	.68	.40	.53	.74	.53	1	.70	.53	.60
FML	.59	.71	.74	.93	.67	.88	.65	.77	.70	1	.65	.89
FVP	.67	.51	.43	.64	.75	.64	.73	.63	.53	.65	1	.65
FVL	.54	.80	.58	.80	.69	.94	.61	.88	.60	.89	.65	1

Note.

P= pictures
L = letters

OSP = ordered spatial pic
OSL = ordered spatial let
OMP = ordered manual pic
OML = ordered manual let
OVP = ordered visual pic
OVL = ordered visual let
FSP = free spatial pic
FSL = free spatial let
FMP = free manual pic
FML = free manual let
FVP = free visual pic
FVL = free visual let

For all correlations $p < .05$ (one-tailed test).

The analysis of the correlational data will focus first on subject characteristics, followed by the recall subtests. The interference effects will be presented next, and finally the phonetic ratio and speech reception threshold will be discussed.

Subject Characteristics

Correlational data regarding age, sex, and IQ provide indications that these variables were associated with recall performance. For the sex variable, there was a low positive correlation in the .2 to .4 range with the recall subtests, with males tending to score higher. A negative correlation of .52 was found between sex and the interference effect, indicating that interference errors were associated more with girls. The finding that girls tended to have lower overall scores, and a greater number of interference errors may be due to the composition of this particular sample of children, since sex differences have not been generally documented. Since this was not a random sample, generalizations should not be made from this information.

Despite the finding that age and IQ showed a negative correlation of -.49, indicating younger children tended to have higher IQ's than older children, older children tended to score better on the recall subtests. Positive correlations ranging from .29 to .56 were found between age and six of the twelve recall subtest scores, with the

highest correlation of .56 between age and free recall of visual pictures. This trend is consistent with other studies, who have found that older deaf children show better recall than younger (Liben, 1979; Liben & Drury, 1977) Age effects have been attributed to more efficient recall strategies in older children.

Recall Subtests

The intercorrelations among the free and ordered recall scores are presented in Table 8. The free recall scores showed moderate to high intercorrelations ranging from .53 to .89. The ordered scores showed a similar pattern with intercorrelations ranging from .57 to .84. The free and ordered scores were also highly correlated, with a range from .40 to .94. The highest correlations were found between the letter subtests for free or ordered recall. These consistent correlations provide support for construct validity of the measures used, in that the tests appear to be measuring a similar ability.

Interference Effects

The interference score shared a moderate inverse relationship with both the free and ordered recall scores for all strategies and materials, ranging from .29 to .47 (Table 7), despite the fact that relatively few of the total errors made were interference errors. Eighteen of the 27

children who showed interference errors made between one and three errors. Of the remaining 9 subjects, 4 made four errors, 2 made five errors, 1 made six errors, 1 made seven errors, and 1 made eight errors. Perhaps the interference errors were associated with lower overall scores as a result of a common process with produced both the interference errors and general difficulties with recall.

Of interest is the negative relationship of -.35 between the phonetic ratio and the interference score (Table 7). This suggests that those children with more verbal processing tended to show smaller interference scores. Similarly, the positive correlation of .26 between the aided hearing loss at 2000 hz and the interference score indicated that as hearing loss became more severe, the interference effect increased. Although these correlations are fairly low, they provide a link between increasing hearing loss, lower phonetic processing, and the interference effect. The correlational pattern between audiological measures and the interference effect leads to the speculation that it may be a phenomenon which is peculiar to deaf children who rely on the use of sign language.

The interference score showed a negative correlation of .42 with IQ. A possible explanation for this is that the combination of factors which produced the interference phenomenon may also have produced recall or processing difficulties which lowered performance on conventional IQ

tests. Many performance IQ measures have a recall component and rely on speed of performance. So, a difficulty which lowers speed or accuracy of recall could lower the IQ score.

Interestingly, IQ was positively correlated with hearing loss in this study, so as hearing loss increased, so did IQ. Although most correlations were positive but nonsignificant, the unaided hearing loss at 2000 hz showed a correlation of .30 with IQ. This finding implies that hearing loss and the interference effect were not spuriously related to IQ; since both higher IQ and larger interference effects were associated with more severe hearing loss; while lower IQ was associated with larger interference effects.

Deaf children tend to show lower recall in comparison to the hearing, particularly with regard to primacy effects in ordered recall (Swanson, 1982). This has led some researchers to suggest that the deaf may have deficiencies in the area of long-term memory in comparison to the hearing (Belmont et al., 1976).

Examination of the serial position of the items which produced interference errors helps reveal whether these errors are related to short or long-term recall. The errors were fairly evenly distributed across the four serial positions. Of the total 78 errors, 20 were items in position 1, 26 in position 2, 13 in position 3, and 20 in position 4.

The presence of interference errors from stimuli in serial position 4 is particularly interesting, since recency

effects have been attributed to this position with the implication that the item in the final position may not be transferred to long-term memory, but is retrieved from the short-term memory buffer. The inability to recall the item immediately, but then recall it in the next trial suggests that the item has entered the long-term store. An error from position 4 also implies that while the child is unable to recall the item, it may be simultaneously transferred to the long-term store, where it is spontaneously recalled in the next series. Particularly for items in position 4, this may indicate difficulties with retrieval from short-term memory. This is not inconsistent with the buffer model which states that items can be held simultaneously in both short and long term memory (Atkinson & Shiffrin, 1977).

For items in serial positions 1 to 3, interference errors may reflect difficulty with retrieval from the long term store, since these items may have already been transferred to the long-term store when recall is attempted. However, the fact that the presence and strength of the phenomenon was associated with lower scores on all the subtests suggests that it may be related in some way to generalized retrieval difficulties in the children who showed the highest interference scores.

When the aspect of spontaneous recall of the item in the next trial is considered, it is more logical that the item was retained in the short-term buffer somehow, rather than

emerging spontaneously from the larger capacity long-term store, where it would be more likely to become "lost". Another possible explanation is that the item stayed in the buffer, but the child experienced retrieval difficulties. Since the series was only 4 items long, there may have been enough buffer capacity for the item to remain there. The child may have continued to consciously or unconsciously scan short-term memory for the missing item, eventually "finding" it to respond on the next trial. Children with this retrieval problem may have also simply forgotten a greater number of items than other children.

Since this study required the children to recall numerous lists in rapid succession; proactive interference, in which previous learning interfers with present learning, may also have contributed in some way to create the interference phenomenon.

Phonetic Ratio and Speech Reception Threshold

The phonetic ratio attempted to measure the degree of verbal processing which children were using, despite severe to profound hearing losses. Conrad (1973) describes this processing as internal speech. He found that almost half of a sample of 43 profoundly (prelingually) deaf college students showed some internal speech, as evidenced by recall of phonologically similar sequences (Conrad, 1973).

Conrad's (1973) study found that pure tone hearing was

not a predictor of internal speech, while speech hearing, and the degree of vocal speech were predictors. In agreement with his findings, the present study found a nonsignificant correlation of .13 between the pure tone average and the phonetic ratio. In comparison, the speech reception threshold and the phonetic ratio shared a significant correlation of .32, indicating that those children who were able to understand some speech through auditory channels also showed a higher phonetic ratio. Although the phonetic ratio in this study was calculated in a different manner than Conrad's Articulatory Index, the similar correlational pattern with hearing loss provides concurrent validity for the phonetic ratio.

Both the phonetic ratio and the speech reception threshold showed a positive correlation with the recall subtest scores, although the phonetic ratio correlations were higher and more consistent across tasks and strategies (Table 7). The phonetic ratio showed significant correlations ranging from .31 to .52 with 11 of the 12 subtest scores, while the speech reception threshold showed positive correlations between .29 and .43 with only 7 of the 12 subtest scores.

One explanation for these results is that the speech reception threshold indicates the potential to use auditory information in learning, while the phonetic ratio provides evidence for functional use of verbal processing or internal

speech, as opposed to potential only. This may explain the phonetic ratio's higher correlation with performance.

Signing deaf children have shown equivalent short-term ordered recall in comparison to oral deaf children (Bebko, 1984). This implies that neither signing or verbal processing offers a natural advantage for short-term recall in the deaf. The finding of verbal processing being associated with better recall in the subgroup of signing deaf children in this study may suggest that the benefit was due to the ability of these children to use multiple encoding strategies, including signing and vocalization or subvocalization. Conrad (1973) found that profoundly deaf signing college students who used internal speech had higher recall for letter sequences. In this study, the highest correlation among the recall subtests (.52) was between the phonetic ratio and ordered visual letters. This was one situation where a vocal or subvocal strategy would be most beneficial, since overt manual rehearsal was prevented.

The correlation between recall performance and the phonetic ratio raises questions regarding the role of speech training with the profoundly deaf. Although the correlation with the speech reception threshold implies that the potential to use phonetic encoding may be determined by the type and degree of hearing loss, the correlation is sufficiently low to admit the influence of other variables. Since speech coding appears to give deaf children more

options for information coding, it would be reasonable to continue speech training in order to maximize any potential which children have to use internal speech, even if their overt speech continues to be unintelligible. One of the variables which could influence the outcome of training, and the phonetic ratio, is IQ.

In Conrad's (1973) study, IQ scores from the nonverbal Cattel test were not correlated with speech coding. Conrad questioned the reliability of the IQ scores in his study, and admitted that this was incongruent with his other findings. In contrast, the present study found a moderate correlation of .42 between the phonetic ratio and performance measures from the WISC-R or Leiter International Performance Scale, indicating that those children with higher IQs also showed higher phonetic ratios. If Conrad's findings were valid, perhaps the finding in this study is due to the age difference between participants in the two studies. During the childhood years, while cognitive styles are developing, IQ may play a relatively greater role than in adulthood, where the effect of years of training and therapy may have compensated to develop internal speech even without the benefit of higher intellectual capacity.

The positive correlation between the phonetic ratio and IQ in children can be explained. If the children who used phonetic processing were more able to use multiple encoding strategies, depending upon the requirements of the task and

situation, this flexibility in cognitive style could also contribute to higher performance on IQ tests, which tend to contain novel and unusual tasks. From another perspective, those children with a higher IQ may also show greater benefits from speech training in order to develop internal speech.

In the present study, the phonetic ratio showed significant correlations with recall subtest scores, while IQ did not. Although IQ and the phonetic ratio may be related with some common processes, perhaps the recall subtests did not require reasoning ability of the type measured by IQ tests. The performance on the recall tasks may have been more influenced by efficiency of encoding strategies, which the phonetic ratio represents. Therefore, although the phonetic ratio and IQ are related, they measure sufficiently different abilities to explain the different correlations with recall.

Summary

The correlational data in this study provided valuable information regarding the interference effect and the phonetic ratio. This information led to speculation regarding the nature of these phenomenon and their relationship to audiological, intellectual, and recall measures.

CHAPTER VI

Conclusions and Implications

The first general conclusion that can be drawn from this study is that there were differential effects among the three encoding strategies for free and ordered recall with this group of deaf children.

Visualization was inferior to both the manual and the spatial strategies for free recall. Differences between the manual and spatial strategies were nonsignificant for free recall, indicating that either the manual or spatial strategy is appropriate to use in free recall tasks.

Ordered recall using the visual strategy was inferior to the spatial strategy for pictures or letters. However, visualization matched the effectiveness of the manual strategy for ordered recall of pictorial material, which was better suited to a visual imagery strategy. Visualization was relatively less effective than the manual strategy for letters, which were less suited to imagery.

The spatial strategy was superior to the manual strategy for ordered recall of pictures. Although the trend favored the spatial strategy, the differences between the manual and spatial strategies were nonsignificant for letters. The benefits associated with the spatial strategy may be due to the kinesthetic and visual sensory input resulting in a

stronger memory trace for recall, better response organization, or both. The source of the advantage for the spatial strategy requires further investigation.

The children in this study showed both primacy and recency effects in short-term recall, in agreement with previous studies (Bellugi et al., 1975; Liben & Drury, 1977; Swanson, 1982). Since the analysis of differing primacy and recency effects was based on trends, rather than statistically significant results, conclusions drawn from the findings are tentative. The hypotheses which were generated should be investigated through further research.

Primacy effects existed for all three strategies and materials with or without obvious rehearsal. Primacy effects in the manual and spatial strategies could be attributed to overt manual rehearsal. However, primacy effects from the visual condition were attributed to internal vocalization, imagery, or increased attention to the initial items in a series. A stronger primacy effect for letters was attributed to the possibility that the static letter handshapes created a stronger image for recall than the more dynamic signs for the pictorial material. A larger recency effect associated with the manual and spatial strategies was attributed to redundancy of the kinesthetic input associated with signing in the manual and spatial strategy, resulting in a stronger image remaining in the short-term memory buffer.

The interference effects which were found in this study presented a phenomenon which had not been described before in the literature. The negative correlation with total recall scores, and IQ suggested that the interference effect may be symptomatic of more pervasive memory processing or retrieval difficulties in the individual. More severe hearing losses and lower phonetic processing were also linked with the interference effect, leading to the speculation that this may be a phenomenon specific to deaf children who rely on the use of sign language. All of these hypotheses require further investigation.

The phonetic ratio was related to speech reception, recall scores, and IQ in this study. The suggestion was made that those children with a higher phonetic ratio may be more able to use multiple encoding strategies, including verbal encoding, depending upon task demands. This cognitive flexibility may contribute to better performance in reasoning and recall tasks. The cognitive benefits of internal speech for the deaf supports the practise of speech training, even for severely and profoundly deaf individuals who show poor speech intelligibility.

Although verbal processing was considered to be an important alternative strategy in some situations, the overall results suggest that the most efficient encoding was through the kinesthetic and proprioceptive channels associated with the manual and spatial strategies. This

lends support to the theory that prelingually deaf individuals who communicate primarily through sign language use an information processing system based upon kinesthetic and proprioceptive sensory input (Karchmer et al., 1981; Stall & Marshall, 1984; Tomlinson Keasey & Kelly, 1978).

Despite the need for more research, the present results suggest that spatial strategies for ordered recall tasks can be directly and practically applied in the classroom. Further, the results suggest that children should be actively involved in manual signing and labelling, rather than passively looking at material to be recalled, since either spatial or manual encoding improved free recall in comparison to visualization only.

As with any study done with a group which has not been randomly selected to represent a known population, caution must be used in generalization of results. The results are applicable to a population of severely to profoundly deaf children between the ages of 6 years 11 months and 12 years 6 months who communicate primarily through sign language, and attend schools for the deaf. Since there may be population differences between segregated and integrated settings, particular caution must be used in application of results to children in integrated educational settings.

Generalizations should also be made to similar types of tasks such as spelling activities, or to recall for lists of items. The results of the present study are not applicable

to text, which involves processing on a deeper semantic level.

Findings regarding the benefits of spatial and manual strategies, primacy and recency effects with manual encoding, interference effects, and the phonetic ratio have all led to hypotheses and speculation regarding the nature of information processing and recall in the deaf child. More research in this area will only contribute to a greater understanding of these children. The goal is to develop better methods to meet the unique learning needs and characteristics of the deaf child. It is hoped that the present study has contributed to this process.

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APPENDIX A

Task Forms

Recall Record Form

Name:_____ Date:_____

Section A: Background Information

1. I.D. number:_____ 2. Age in months:_____
3. Sex:_____
4. Aided hearing loss 2000 hz:_____
5. Unaided hearing loss 2000 hz:_____
6. Pure Tone Average:_____
7. Speech awareness threshold:_____
8. WISC IQ:_____ Leiter IQ:_____
10. Test order: Visual:_____ Spatial:_____ Manual:_____
11. Stimulus Order: Letters_____ Pictures_____

Section B: Results

I Ordered Recall

	Visual		Spatial		Manual	
	Pictures	Letters	Pictures	Letters	Pictures	Letters
1	_____	_____	_____	_____	_____	_____
2	_____	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____	_____
4	_____	_____	_____	_____	_____	_____
Tot	_____	_____	_____	_____	_____	_____

Tot Vis:_____ Tot Spat:_____ Tot Man_____

Manual:_____

Total Pictures from all conditions:_____

Total Letters from all conditions:_____

Grand total Ordered Recall:_____

II Free Recall

	Visual		Spatial		Manual	
	Pictures	Letters	Pictures	Letters	Pictures	Letters
1	_____	_____	_____	_____	_____	_____
2	_____	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____	_____
4	_____	_____	_____	_____	_____	_____
Tot	_____	_____	_____	_____	_____	_____

Tot Vis:_____ Tot Spat:_____ Tot Man_____

Manual:_____

Total Pictures from all conditions:_____

Total Letters from all conditions:_____

Grand total Free Recall:_____

III Interference Effects With Pictures

Visual:_____

Spatial:_____

Manual:_____

Total:_____

Picture Recognition Pretest

Name:_____ Date:_____
Key: Checkmark - uses correct sign
IS- invented sign or substitution, described

1. Woman:_____
2. Cat:_____
3. Spoon:_____
4. Chair:_____
5. Banana:_____
6. Fish:_____
7. Sock:_____
8. Pencil:_____
9. Butterfly:_____
10. Apple:_____
11. Table:_____
12. Doll:_____
13. Car:_____
14. Clown:_____
15. Sailboat:_____
16. Keys:_____
17. Toys:_____
18. Ball:_____
19. Cup:_____
20. Boot or shoe:_____
21. Broom:_____
22. Dog:_____
23. Truck:_____
24. Baby:_____
25. Bat:_____
26. Wagon:_____
27. Tree:_____
28. Knife:_____
29. Soap:_____
30. Cow:_____
31. Bus:_____
32. Flower or rose_____
33. Picture:_____
34. House:_____
35. Bicycle:_____
36. Kangaroo:_____
37. Alligator:_____
38. Kite:_____
39. Hotdog:_____
40. Sheep:_____
41. Train:_____
42. Eagle or bird:_____
43. Giraffe:_____
44. Man:_____
45. Queen:_____

46. Shovel:_____
47. Letter:_____
48. Saw:_____
49. Pitcher:_____
50. Iron:_____
51. Necklace:_____
52. Corn:_____
53. Deer:_____
54. Horse:_____
55. Scissors:_____
56. Peas:_____
57. Drum: _____
58. Ring:_____
59. Skirt:_____
60. Jacket:_____
61. Mitten:_____
62. Belt:_____
63. Axe:_____
64. Fence:_____
65. Snake:_____
66. Duck:_____
67. Bee:_____
68. Vegetables:_____
69. Mountains:_____
70. Fan:_____
71. Bear:_____
72. Squirrel:_____
73. Turtle:_____
74. Bell:_____
75. Pie:_____

Raw Data Form A- Pictures

Name:_____ I.D.:_____ Date:_____
Order: 1._____ 2._____ 3._____ 4._____ 5._____ 6._____
Strategy: Spatial _____ Visual _____ Manual _____
Trial: 1.shoe_____ 2.spoon_____ 3.turtle_____4. doll_____

Test:

#1.	1. deer	2. scissors	3. kite	4. ring
	1. _____	2. _____	3. _____	4. _____
#2.	1. drum	2. necklace	3. man	4. axe
	1. _____	2. _____	3. _____	4. _____
#3.	1. shovel	2. flower	3. banana	4. bee
	1. _____	2. _____	3. _____	4. _____
#4.	1. mountains	2. horse	3. bus	4. brush
	1. _____	2. _____	3. _____	4. _____
#5.	1. sheep	2. ball	3. letter	4. woman
	1. _____	2. _____	3. _____	4. _____
#6.	1. skirt	2. chair	3. car	4. queen
	1. _____	2. _____	3. _____	4. _____
#7.	1. picture	2. mitt	3. eagle	4. fish
	1. _____	2. _____	3. _____	4. _____
#8.	1. baby	2. dog	3. saw	4. hotdog
	1. _____	2. _____	3. _____	4. _____
#9.	1. pie	2. sailboat	3. fence	4. cow
	1. _____	2. _____	3. _____	4. _____
#10.	1. jacket	2. train	3. table	4. toys
	1. _____	2. _____	3. _____	4. _____
#11.	1. clown	2. alligator	3. sock	4. cup
	1. _____	2. _____	3. _____	4. _____
#12.	1. belt	2. vegetables	3. pencil	4. butterfly
	1. _____	2. _____	3. _____	4. _____
#13.	1. bat	2. keys	3. corn	4. squirrel
	1. _____	2. _____	3. _____	4. _____
#14.	1. tree	2. bicycle	3. cat	4. apple
	1. _____	2. _____	3. _____	4. _____

#15.	1. knife	2. bear	3. truck	4. iron
	1. _____	2. _____	3. _____	4. _____
#16.	1. giraffe	2. fan	3. peas	4. house
	1. _____	2. _____	3. _____	4. _____

Raw Data Form B- Pictures

Name:_____ I.D.:_____ Date:_____
Order: 1._____ 2._____ 3._____ 4._____ 5._____ 6._____
Strategy: Spatial _____ Visual _____ Manual _____
Trial: 1. pencil_____ 2. chair_____3.train____4.horse_____

Test:

#1.	1. bear	2. saw	3. baby	4. sailboat
	1. _____	2. _____	3. _____	4. _____
#2.	1. hot dog	2. brush	3. dog	4. clown
	1. _____	2. _____	3. _____	4. _____
#3.	1. alligator	2. bat	3. shovel	4. sock
	1. _____	2. _____	3. _____	4. _____
#4.	1. bus	2. duck	3. picture	4. belt
	1. _____	2. _____	3. _____	4. _____
#5.	1. queen	2. ring	3. peas	4. spoon
	1. _____	2. _____	3. _____	4. _____
#6.	1. car	2. fish	3. letter	4. woman
	1. _____	2. _____	3. _____	4. _____
#7.	1. eagle	2. toys	3. skirt	4. fan
	1. _____	2. _____	3. _____	4. _____
#8.	1. knife	2. mountains	3. bell	4. kite
	1. _____	2. _____	3. _____	4. _____
#9.	1. scissors	2. bee	3. flower	4. banana
	1. _____	2. _____	3. _____	4. _____
#10	1. house	2. cat	3. mitt	4. drum
	1. _____	2. _____	3. _____	4. _____
#11	1. apple	2. necklace	3. man	4. turtle
	1. _____	2. _____	3. _____	4. _____
#12	1. tree	2. sheep	3. doll	4. truck
	1. _____	2. _____	3. _____	4. _____
#13.	1. deer	2. keys	3. cup	4. bicycle
	1. _____	2. _____	3. _____	4. _____
#14	1. jacket	2. corn	3. giraffe	4. ball
	1. _____	2. _____	3. _____	4. _____

#15. 1. vegetables 2. table 3. butterfly 4. pie
1. _____ 2. _____ 3. _____ 4. _____

#16. 1. wagon 2. fence -- 3. cow 5. iron
1. _____ 2. _____ 3. _____ 4. _____

Raw Data Form C- Pictures

Name:_____ I.D.:_____
Date:_____
Order: 1._____ 2._____ 3._____ 4._____ 5._____ 6._____.
Strategy: Spatial _____ Visual _____ Manual _____
Trial: 1.car_____ 2.vegetables_____3.cow_____4.spoon_____

Test:

#1.	1. snake	2. sock	3. bell	4. cup
	1. _____	2. _____	3. _____	4. _____
#2.	1. pie	2. man	3. turtle	4. mitt
	1. _____	2. _____	3. _____	4. _____
#3.	1. hotdog	2. skirt	3. horse	4. bus
	1. _____	2. _____	3. _____	4. _____
#4.	1. iron	2. apple	3. ring	4. kite
	1. _____	2. _____	3. _____	4. _____
#5.	1. necklace	2. bicycle	3. flower	4. peas
	1. _____	2. _____	3. _____	4. _____
#6.	1. doll	2. duck	3. belt	4. butterfly
	1. _____	2. _____	3. _____	4. _____
#7.	1. baby	2. fish	3. dog	4. sailboat
	1. _____	2. _____	3. _____	4. _____
#8.	1. queen	2. pencil	3. table	4. deer
	1. _____	2. _____	3. _____	4. _____
#9.	1. jacket	2. fence	3. picture	4. bee
	1. _____	2. _____	3. _____	4. _____
#10.	1. clown	2. sheep	3. tree	4. drum
	1. _____	2. _____	3. _____	4. _____
#11.	1. mountains	2. boot	3. chair	4. squirrel
	1. _____	2. _____	3. _____	4. _____
#12.	1. house	2. saw	3. bear	4. truck
	1. _____	2. _____	3. _____	4. _____
#13.	1. keys	2. banana	3. fan	4. ball
	1. _____	2. _____	3. _____	4. _____
#14.	1. train	2. bat	3. toys	4. cat
	1. _____	2. _____	3. _____	4. _____

#15. 1. kangaroo 2. letter 3. knife 4. corn
1. _____ 2. _____ 3. _____ 4. _____

#16. 1. wagon 2. eagle 3. giraffe 4. scissors
1. _____ 2. _____ 3. _____ 4. _____

Raw Data Form A- Letters

Name:_____ I.D.:_____
Date:_____
Order: 1._____ 2._____ 3._____ 4._____ 5._____ 6._____
Strategy: Spatial _____ Visual _____ Manual _____
Trial: 1. L_____ 2. Q_____ 3. F_____ 4. J_____

Test:

#1.	1. Y	2. K	3. M	4. A
	1. _____	2. _____	3. _____	4. _____
#2.	1. G	2. P	3. T	4. B
	1. _____	2. _____	3. _____	4. _____
#3.	1. M	2. X	3. W	4. N
	1. _____	2. _____	3. _____	4. _____
#4.	1. B	2. T	3. C	4. E
	1. _____	2. _____	3. _____	4. _____
#5.	1. N	2. W	3. A	4. Z
	1. _____	2. _____	3. _____	4. _____
#6.	1. D	2. B	3. P	4. C
	1. _____	2. _____	3. _____	4. _____
#7.	1. A	2. Y	3. Z	4. X
	1. _____	2. _____	3. _____	4. _____
#8.	1. C	2. V	3. E	4. D
	1. _____	2. _____	3. _____	4. _____
#9.	1. Z	2. M	3. K	4. W
	1. _____	2. _____	3. _____	4. _____
#10.	1. T	2. G	3. D	4. P
	1. _____	2. _____	3. _____	4. _____
#11.	1. X	2. A	3. N	4. K
	1. _____	2. _____	3. _____	4. _____
#12.	1. E	2. C	3. V	4. G
	1. _____	2. _____	3. _____	4. _____
#13.	1. W	2. Z	3. Y	4. M
	1. _____	2. _____	3. _____	4. _____
#14.	1. V	2. E	3. B	4. T
	1. _____	2. _____	3. _____	4. _____

#15.1. K 2. N 3. X 4. Y
1. _____ 2. _____ 3. _____ 4. _____

#16.1. P 2. D 3. G 4. V
1. _____ 2. _____ 3. _____ 4. _____

Raw Data Form B- Letters

Name:_____ I.D.:_____
Date:_____
Order: 1._____ 2._____ 3._____ 4._____ 5._____ 6._____
Strategy: Spatial _____ Visual _____ Manual _____
Trial: 1.I_____ 2. H_____ 3. U_____ 4. S_____

Test:

#1.	1. K	2. A	3. X	4. Z
	1. _____	2. _____	3. _____	4. _____
#2.	1. T	2. V	3. P	4. G
	1. _____	2. _____	3. _____	4. _____
#3.	1. X	2. Z	3. W	4. Y
	1. _____	2. _____	3. _____	4. _____
#4.	1. P	2. B	3. D	4. V
	1. _____	2. _____	3. _____	4. _____
#5.	1. Y	2. N	3. M	4. A
	1. _____	2. _____	3. _____	4. _____
#6.	1. V	2. C	3. G	4. D
	1. _____	2. _____	3. _____	4. _____
#7.	1. M	2. W	3. Y	4. X
	1. _____	2. _____	3. _____	4. _____
#8.	1. B	2. D	3. E	4. C
	1. _____	2. _____	3. _____	4. _____
#9.	1. Z	2. K	3. N	4. W
	1. _____	2. _____	3. _____	4. _____
#10.	1. G	2. E	3. C	4. P
	1. _____	2. _____	3. _____	4. _____
#11.	1. N	2. Y	3. A	4. K
	1. _____	2. _____	3. _____	4. _____
#12.	1. E	2. P	3. T	4. B
	1. _____	2. _____	3. _____	4. _____
#13.	1. A	2. X	3. Z	4. M
	1. _____	2. _____	3. _____	4. _____
#14.	1. C	2. T	3. V	4. E
	1. _____	2. _____	3. _____	4. _____

#15. 1. W 2. M 3. K 4. N
1. _____ 2. _____ 3. _____ 4. _____

#16. 1. D 2. G 3. B 4. T
1. _____ 2. _____ 3. _____ 4. _____

Raw Data Form C - Letters

Name:_____ I.D.:_____
Date:_____
Order: 1._____ 2._____ 3._____ 4._____ 5._____ 6._____
Strategy: Spatial _____ Visual _____ Manual _____
Trial: 1. O_____ 2. I_____ 3. U_____ 4. R_____

Test: --

#1.	1. A	2. Y	3. N	4. K
	1. _____	2. _____	3. _____	4. _____
#2.	1. B	2. D	3. G	4. E
	1. _____	2. _____	3. _____	4. _____
#3.	1. X	2. N	3. W	4. Z
	1. _____	2. _____	3. _____	4. _____
#4.	1. E	2. B	3. P	4. T
	1. _____	2. _____	3. _____	4. _____
#5.	1. W	2. Z	3. M	4. X
	1. _____	2. _____	3. _____	4. _____
#6.	1. D	2. P	3. V	4. G
	1. _____	2. _____	3. _____	4. _____
#7.	1. K	2. A	3. Z	4. M
	1. _____	2. _____	3. _____	4. _____
#8.	1. C	2. E	3. B	4. V
	1. _____	2. _____	3. _____	4. _____
#9.	1. M	2. K	3. Y	4. N
	1. _____	2. _____	3. _____	4. _____
#10.	1. P	2. C	3. T	4. D
	1. _____	2. _____	3. _____	4. _____
#11.	1. Z	2. X	3. A	4. W
	1. _____	2. _____	3. _____	4. _____
#12.	1. V	2. T	3. D	4. B
	1. _____	2. _____	3. _____	4. _____
#13.	1. N	2. W	3. K	4. Y
	1. _____	2. _____	3. _____	4. _____
#14.	1. G	2. V	3. C	4. P
	1. _____	2. _____	3. _____	4. _____

#15. 1. Y 2. M 3. X 4. A
1. _____ 2. _____ 3. _____ 4. _____

#16. 1. T 2. G 3. E 4. C
1. _____ 2. _____ 3. _____ 4. _____

APPENDIX B

Task Instructions

Introduction

The child is seated at the testing table. He is first asked to identify the master list of pictures. Then, for the first subtest, either pictures or letters may be administered.

NOW I WILL SHOW YOU SOME PICTURES/LETTERS THAT YOU MUST TRY TO REMEMBER. YOU WILL NEED TO REMEMBER 4 PICTURES/LETTERS EACH TIME.

The child is then given instructions for either the spatial, manual or visual strategy which has been randomly chosen for the child. Following specific instructions for each strategy, the child is told:

IT IS IMPORTANT THAT YOU COOPERATE AND REALLY PAY ATTENTION. TRY YOUR BEST TO REMEMBER THEM ALL. ARE YOU READY TO BEGIN? NOW TRY TO REMEMBER THE NAME OF EACH PICTURE/LETTER THAT YOU SEE. REMEMBER WHICH ONE IS FIRST, SECOND, THIRD AND FOURTH. YOU MUST TELL ME THE NAMES OF THE PICTURES/LETTERS THE SAME WAY THAT YOU SEE THEM.

The practise trial is repeated with the new strategy until the child attains a perfect response on the practise trial, and fully understands what is expected for that strategy. The formal test is administered as soon as the practise trial is completed. A practise trial is given with both pictures and letters for each strategy.

For all strategies, the child is allowed to respond only after a blank slide is projected, following the test

sequence.

Visual Strategy

NOW WE WILL SEE SOME PICTURES/LETTERS. I WANT YOU TO FOLD YOUR HANDS LIKE THIS (demonstrate). MAKE SURE YOU KEEP YOUR HANDS FOLDED UNTIL I ASK YOU TO TELL ME THE NAMES OF THE PICTURES. REMEMBER YOU CAN'T SIGN THE NAME OF THE PICTURES.

Manual Strategy

NOW WHEN YOU SEE EACH PICTURE/LETTER, I WANT YOU TO MAKE THE SIGN FOR IT. (The appropirate trial sequence is demonstrated and the child is prompted to sign each object as the slide appears).

Spatial Strategy

NOW WHEN YOU SEE EACH PICTURE/LETTER, I WANT YOU TO SIGN THE NAME OF THE PICTURE/LETTER AND POINT TO THE SQUARE HERE (point to the sectioned card fastened to the table in front of the child) WHERE THE PICTURE SHOULD BE. START HERE (far left).

The practise trial is demonstrated, and the child is prompted to sign the name of the object and point to the appropriate spot on the sectioned card.

APPENDIX C

ANOVA Summary Tables For Recall Data

Table C-1

ANOVA for Free Recall

Involving 2 (Tasks) X 3 (Strategies)

Source	df	MS	F
Within			
A (Task)	1/35	693.28	10.62***
Error		65.30	
B (Strategy)	2/70	455.13	16.43***
Error		27.70	
A X B	2/70	2.25	.13
Error		16.81	

(N = 36)

* = p<.05

** = p<.01

*** = p<.001

Table C-2

ANOVA for Ordered Recall

Involving 2 (Tasks) X 3 (Strategies)

Source	df	MS	F
Within			
A (Task)	1/35	1102.50	13.46***
Error		81.91	
B (Strategy)	2/70	2387.18	27.41***
Error		87.08	
A X B	2/70	326.81	9.10***
Error		35.93	

(N = 36)

* = p<.05

** = p<.01

*** = p<.001

Table C-3

ANOVA for Free Recall

Involving 4 (Positions) X 2 (Tasks) X 3 (Strategies)

Source	df	MS	F
Within			
A (Task)	1/35	185.19	11.54**
Error		16.05	
B (Strategy)	2/70	107.70	15.67***
Error		6.87	
A X B	2/70	.62	.15
Error		4.13	
C (Position)	3/105	81.20	8.28***
Error		9.87	
A X C	3/105	34.05	8.24***
Error		4.13	
B X C	6/210	2.11	.51
Error		4.14	
A X B X C	6/210	7.67	2.314*
Error		3.32	

(N = 36)

* = p<.05

** = p<.01

*** = p<.001

Table C-4

ANOVA for Ordered Recall

Involving 4 (Positions) X 2 (Tasks) X 3 (Strategies)

Source	df	MS	F
Within			
A (Task)	1/35	271.13	13.20***
Error		20.54	
B (Strategy)	2/70	596.20	27.71***
Error		21.52	
A X B	2/70	80.23	8.97***
Error		8.94	
C (Position)	3/105	464.50	104.18***
Error		4.46	
A X C	3/105	10.21	3.49*
Error		2.93	
B X C	6/210	49.77	13.35***
Error		3.73	
A X B X C	6/210	15.69	5.48***
Error		2.86	

(N = 36)

* = p<.05

** = p<.01

*** = p<.001